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Editor:

CHARLES LANE POOR

New York
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VOL. XVI PART I

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The Academy will meet on Monday evenings at 8.15 o'clock, from October to May, in the American Museum of Natural History, **77th Street and Central Park, West.**

[ANNALS N. Y. ACAD. SCI., VOL. XVI, No. 1, pp. 1–64, February 8, 1905.]

THE HISTORY OF THE GERM CELLS IN PEDICELLINA AMERICANA (LEIDY).

LOUIS I. DUBLIN.

CONTENTS.

(With Pl. I, II, III, and 2 figs. in text.)

Preface.

In the following study I have endeavored to follow out, as fully as possible, the history of the germ cells in *Pedicellina* from the point of view that has been suggested by the recent work of Montgomery, Sutton and Boveri. In line with the work of the first two, my principal aim has been to examine the reduction problem and especially the process of synapsis, where, according to these authors, the reduction occurs. It is due to them that the proper attention has been attracted to the study of the earlier generations of the germ cells where the beginnings of the processes that culminate in the later maturation phenomena may be observed. Such a study, as far as the material permitted, I have attempted to make, and what are perhaps the most significant results of this study were thus obtained.

The conclusions of these authors involve as a fundamental principle, the likeness of the processes in the history of the egg- and the sperm-nuclei. Yet not since the work of Hertwig and Boveri, more than a decade ago, has a work of any completeness on both oögenesis and spermatogenesis, in the same animal, appeared. Indeed, with the exception of *Ascaris* and a few other forms, on which isolated observations have been made, in no one species has the history of the chromatin been studied throughout. For such a purpose *Pedicellina americana* is in several respects very favorably adapted. While neither the male nor the female germ-cells are in this form especially large, all the stages in development from the larva to the mature polyp are available, making it possible to follow the processes with comparative ease, from the very beginnings of the differentiation of the germ-cells up to fertilization. Fertilization and development of the embryo, moreover, occur within the maternal brood pouch ; and this, coupled with the comparatively small size of the individual polyp, makes possible a very direct comparison between the nuclear changes in the so-

matic and germ-cells. The complete cycle of chromatic changes, from one generation to the succeeding one, may therefore be traced.

Under such conditions as these, it was my hope that *Pedicellina* would be a favorable object for the further study of the problem proposed by Häcker, viz., the fate of the maternal and paternal chromatin elements in the offspring. This, however, proved not to be the case, though some suggestive conditions have been observed. My principal study has, therefore, been devoted to the history of the chromatin of the germ-cells. These show remarkable similarity in their development in the two sexes, and give results corroborative of those of Montgomery and Sutton. Finally, the processes of fertilization and early cleavage are described ; attention is drawn to the character of the nucleolus, and to the individuality of the chromosomes throughout the whole course of development.

It gives me much pleasure to express my obligations to the staff of the Department of Zoölogy in Columbia University, to whom I owe my appointment as the John D. Jones Scholar at the Cold Spring Harbor Laboratory ; but above all to Professor E. B. Wilson, to whom my sincerest thanks are due. From the very beginning he has spared neither time nor effort in his guidance of the research ; and to him also do I owe a careful revision of my manuscript both in word and in substance.

I. Material and Methods.

The material for this study was obtained at Cold Spring Harbor, Long Island, where *Pedicellina* occurs at several places in the harbor. Thanks to the kindly interest of Professor C. B. Davenport, the Director of the laboratory, a most favorable spot was located where the colonies could be obtained in great abundance. This was in an oyster-bed, lying in a shallow channel separating the inner from the outer harbor, where the material could be collected at low tide, in any quantity, by removal from the oyster-shells which the colonies encrusted. The breeding season is a fairly long one ; beginning about the

middle of June and continuing until the first week in August, when most of the mature males were found almost entirely spent and the free swimming larvæ were no longer in the tow. Owing to the extremely delicate nature of the polyp, the material was fixed immediately upon arrival at the laboratory. For this purpose, corrosive sublimate with five per cent. acetic was mainly employed and gave excellent results, the cells within the ovary and testis showing almost no displacement or contraction.

Many stains were employed, among others, Heidenhain's hæmatoxylin, Auerbach's fluid, thionin, and Flemming's triple stain, but the first gave by far the best results. In the study of the spermatogenesis, this stain was indispensable. Thionin gave very useful results, particularly in the maturation process of the egg, since the large yolk spheres are almost unstained, while the chromosomes are sharply brought out. By the proper use of the Heidenhain's hæmotoxylin, however, the yolk could be made to take a dark brown, while the chromatin stained intensely black. This method had the advantage of permanency and of bringing out the achromatic structures which the thionin could not be made to do. Auerbach's fluid was used mainly as a chromatin test and gave, on the whole, consistent results. The colonies were imbedded and sectioned *en masse* (sections of 5 mi. thickness), and in this way there were obtained on the same slide, male and female individuals of all ages, sometimes presenting within the same field, nearly all the phases with which this paper is concerned.

II. Sex Relations Within the Colony.

In *Pedicellina americana*, as in *Ascopodaria macropus*, another of the *Pedicellinidæ*, described by Ehlers, '90, both male and female polypides may occur on the same stolon. Since the colony arises through the budding of a single primary polyp, the determination of sex in this form presents a somewhat interesting problem, particularly from the point of view suggested by the recent discussions on the question of sex by Cuénot, '99, Lenhossek, '00, Castle, '03, Schultze, '03, and

others, who have urged the probability that sex is not directly subject to the action of external stimuli, but is rather inherent in the germ-cells.

The relations described in *Pedicellina* may best be interpreted in the light of the facts observed in other colonial forms. Throughout the Cœlenterata, with the exception of such hemaphrodites as *Chrysaora* and *Hydra* and such colonies as *Corallium rubrum* and some of the *Sertularia* (cf. Cuénot), the individuals of a colony are all of the same sex. In the Ectoproctous Bryozoa and the Tunicates, on the other hand, the conditions are still simpler, for among these the individuals are all hermaphroditic. In the Endoprocta all possible conditions as to sex exist, as the following *resumé* will show.

In *Loxosoma annelidicola*, the individuals, according to Prouho, '01, are all of one and the same sex. No permanent colony is formed. *Loxosoma davenporti*, as described by Nickerson, '01, is hermaphrodite throughout, but there is distinct proterogyny. In like manner, Harmer, '85, found in *L. pes* and in other species of this same genus, hermaphroditism, with a decided proterandry. Finally, in *L. raja*, as early described by Schmidt, '76, simple hermaphroditism prevails. In the genus *Pedicellina* proper, like variations occur. According to both Nitsche, '69, and Hatschek, '77, the individuals of *P. echinata* are hermaphrodite, while according to the late investigation of Harmer '85, and Fœttinger, '87, they are of one sex. The weighty opinion of Ehlers, '90, however, who himself investigated the problem, is on the side of the former. A like difference of opinion is found in connection with *P. benedeni* which, according to Fœttinger, is diœcious, but by Ehlers is as positively regarded as monœcious. *P. belgica*, on the former authority, is also diœcious, while on that of the latter, *P. glabra*, is monœcious. Finally, in *P. americana*, and in the nearly allied *Ascopodaria macropus*, the individuals are always either male or female, but both may occur in the same colony.

The disagreement that exists among the different authorities mentioned, concerning the sex of a considerable number of forms, is a striking fact. It is difficult to suppose that good

observers could have erred regarding the true condition of a character so obvious in mature individuals of all of the Endoprocta. It is more probable that in the disputed cases there is true hermaphroditism disguised by proterandry or proterogyny. Thus Ehlers, '90, suggests the possibility that, "in verschiedenen Jahreszeiten, die Stöcke etwa ungleich sexuirte Nährthiere erzeugten, so dass, zu der einen Zeit, gonochoristische (diœcious), zu einer anderen Zeit, hermaphroditische Kelche vorhanden sind." In like manner, Nickerson, '01, points out that "several periods of sexual activity, alternately male and female, may occur in the same animal."

These explanations, if accepted, would add to the already large number of cases of true hermaphroditism. For if an individual, at one time male, can at a later period become female, then it must be clear that the germ-cells of the two sexes really occur side by side in the same polypide, but the height of the developmental period of the two does not occur at the same time. This would make it very probable that hermaphroditism is the primitive condition among the Endoprocta from which, the several exceptions have to a greater or less extent diverged.

It is this hypothesis which will be applied as an explanation of the peculiar conditions observed in *Pedicellina americana.* This species may be considered as hermaphrodite, but both sexes do not develop at the same time, nor in the same individual of the colony. There is in the very young primary polypide a mosaic condition of the germ-cells, *i. e.*, there are both primary egg and sperm-cells present side by side. In the process of growth, only one portion of these develops into a mature ovary or testis, the other remaining indistinguishable as a few primary germ-cells among the other embryonic cells of the body. With the budding, which now ensues, these are carried into the newly formed individual with some of the primary cells of the other sex; but here, these may, in response to some change in the local conditions, become active and the others latent thus giving rise to a sex opposite to that of the preceding individual. This process may, however, occur for the first time, in the second or in some later budding in the life history of the colony or, in some cases, not at all.

That this view is probably expressive of the truth is to be inferred from the existence, in the same and in allied genera, of all the necessary transitions between the primitive conditions observed in the majority of forms, on the one hand, and the specialized condition of *P. americana* and *Ascopodaria macropus* on the other. Beginning with *P. glabra*, where the individuals, as well as the colony, are all monœcious, the series leads directly to those where, as in *P. echinata* proterandry or proterogyny sets in, and finally becomes distinctive of the species. In the genus *Loxosoma*, this is the all prevailing form in which the hermaphroditism is found. Thus Harmer writes of this genus: "I have invariably found that mature ovaries and testes are mutually exclusive. It is easily shown that individuals containing developing embryos in their vestibule are not provided with testes in the species of *Loxosoma* and *Pedicellina* which I have examined. In some cases, a vesicula seminalis containing spermatozoa is found, although the testes seem to be completely absent. This fact, perhaps, indicates that the male gonads, which must have been originally present, have atrophied in order to make room for the development of the ovaries." We have now only to suppose that this proterandry or proterogyny of the colony is distributed over several individuals instead of being localized in one, and the condition found in *P. americana* is obtained. The extension of the period between the development of the germ-cells of the two sexes is probably in response to some change in the relation of the zoöids to the colony as a whole in which process the latter becomes more highly individualized.

This condition can finally be traced one step further where, as in a form like *P. belgica* or *Loxosoma annelidicola*, one or the other of the sexes never develops, leaving both the polyps and the colony diœcious. This is the end of the series. It has therefore been shown that in the Endoproctous Bryozoa, all possible relations of the germ cells in single individuals and groups of individuals exist, and that from the primitive condition of complete monœciousness, a full series of transitions can be traced to as complete diœciousness. There is, however, an

error into which it is easy to fall in considering the sex conditions of *P. americana*, viz., to suppose, in the light of the Mendelian principles expressed in Castle's paper on the Heredity of Sex, that there is an alternation of dominance and recession of one sex or the other. This interpretation is made impossible from the conditions described in the allied forms and one is forced to the conclusion already adopted above, that there is a true mosaic of sex in which the elements are widely scattered in time and place. The colony as a whole, is now an hermaphroditic individual.

III. Spermatogenesis.

The testis of *Pedicellina americana* is a paired bilaterally symmetrical organ situated in the space between the liver cells and the atrium. At the center, between the two component halves, lies the vas deferens, through which the ripe spermatozoa make their way directly into the atrium and thence to the outside. The two halves are pear-shaped with the broader ends closely apposed to the body wall of the polyp, from which they are separated by a thin layer of epithelial cells surrounding the entire structure. It is interesting, in the study of the living individuals, to observe the mechanism by which the extrusion of the spermatozoa is accomplished. Upon slight provocation, such as touching the polyp with a needle point, the tentacles are immediately drawn in, and simultaneously the calyx is much contracted. This is followed by an extrusion of the ripe spermatozoa in dense clouds, through the atrium. During this process of extrusion, also, the polyp is subjected to a change of position by the rapid movements of the stalk.

In a longitudinal or transverse section of such a polyp, the internal relations of the testis can be very readily made out. There is nothing corresponding to a subdivision of this organ into compartments, as in so many forms; nor is there any arrangement of the germ cells with respect to age, the cells lying scattered irregularly throughout. The great number of developing cells is very striking. In a fairly large individual the testes filled with densely crowded cells take up by far the greatest portion of the calyx, and compress on all sides the other organs of the body.

Under such conditions it is rather difficult to determine the proper sequence of the divisions ; yet this difficulty can be, in a great measure, overcome by examining the different degrees of development within the different polypides. Thus, where there is no line or series of progressive development within the testis itself, an artificial series can be constructed from the youngest to the oldest testes. Accordingly, I shall first describe the condition to be found in a very young polyp — one shortly after the period of metamorphosis. Here, lying in their proper place, are the primary sperm cells from which all the later generations will arise. These cells are nearly all in the resting stage, and have not as yet sufficiently increased in numbers to fill up the space inclosed by the germinal epithelium. In a somewhat older individual, the majority of the germ cells (Fig. 1, Pl. I) are much larger and now completely fill up the halves of the small testis. They are, in size and general appearance, like a great number of cells always found within the testes of mature individuals, and are undoubtedly an early generation of spermatogonia. In similar female polyps, the corresponding germ-cells are always larger and are not so closely crowded together. Comparatively few cells are in division. The majority, as appears from the figure, remain for considerable periods in the resting stage, and may be everywhere recognized by the large size of their nuclei in relation to the cytoplasm, the lightly staining chromatin reticulum, and finally by the presence of a pair of deeply staining plasmosomes or nucleoli. These arise very early near opposite points on the nuclear membrane as small bodies and increasing in size, make their way to the center of the cell where they fuse into one larger and more irregular mass.

With the increase in the size of the testis, it is quite clear, from the several sizes of the cells, that there are several generations of spermatogonia. The largest, which predominates, is in all respects like the first generation of spermatogonia observed in the above Fig. 1. It is therefore clear that in the transition between these two stages only a few of the early cells divide at one time to give rise to the later generations. This

fact is most strikingly brought out in connection with the older testes. Here mature spermatozoa are often found surrounding spermatogonia of this early generation. The latter evidently remain latent and develop only when room is made for them by the discharge of ripe spermatozoa.

Leaving out the slight differences in size, these different generations are all of the same type in both the resting and division stages with the important exception of the one, which from its smallest size, I take to be the last. In the prophases and metaphases of all but the last of these, the chromosomes appear everywhere as V's, with their apices directed toward the spindle, (Figs. 2–6) and cannot be distinguished by any structural differences from the figures in the somatic mitoses. The number is clearly unreduced, and by the study of many division figures is determined as twenty-two. They split longitudinally, and in the anaphase (Fig. 7), are seen with their angles turned toward the poles. In the telophase (Fig. 8), the twenty-two small bodies are concentrated very closely, and with the chance exception of some belated ones, cannot be made out individually.

In the last generation, the character of the mitosis shows a marked contrast to the preceding ones. The chromosomes are, in the metaphase, in nearly every case, no longer V-shaped but thickened dumb-bell shaped bars (Figs. 9–12). It is important to observe that these often show a constriction in the middle which, may correspond to the apex of the earlier V's. These split longitudinally, and in the early anaphase (Fig. 13) the unreduced number of rods appears, presenting a striking difference from the other previous spermatogonial figures. It must be stated at this point, however, that in one or two instances I have found one or two chromosomes in the metaphase of the last division not as yet converted into the bars. This, together with the fact that some straight rods are occasionally found in spindles, which, from consideration of size, I think are of the penultimate generation, would tend to show that this conversion of the type of the chromosome is not a sudden process, but is perhaps carried over a considerable period, being most pronounced and finding its completion in

the last division. The chromosomes now come closer together along the converging spindle-fibers (Figs. 14–16) and finally, in the early telophase (Figs. 17–18), appear at each pole, in the form of about eleven (the reduced number) of V's. Owing to the increased size of the individual chromosomes, and the corresponding halving of their number, the concentration in the telophase into one impenetrable mass, so characteristic of the earlier generations of spermatogonia, is not so marked. As the several figures show, the chromosomes are, in most cases, individually distinguishable, and (as in both cells of Fig. 18) can readily be studied. The evidence therefore, unmistakably indicates that the eleven V's have arisen from the twenty-two rod-shaped bodies, which have united end to end during the latter part of the process of division; and that, as in *Peripatus* and the other forms studied by Montgomery, the reduction takes place at this point. The true "synapsis" is therefore not to be sought in some stage in the early growth period of the spermatocyte, but in the latter half of the last spermatogonial division, as Montgomery and Sutton have insisted.

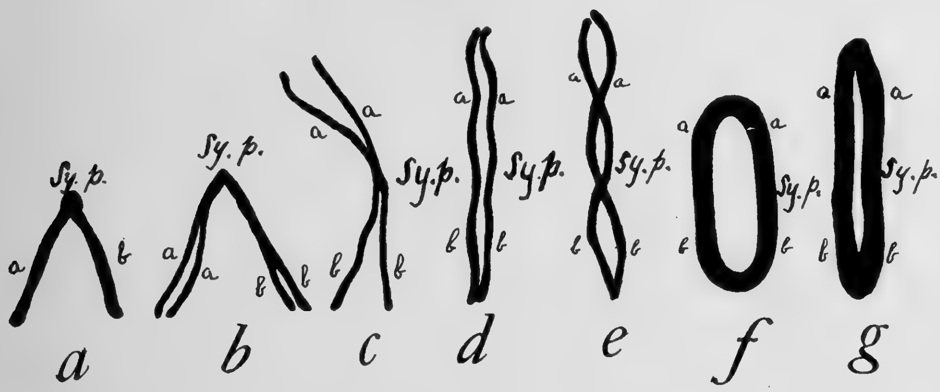
After the process of synapsis, the nuclear membrane reforms and the spermatogonia are now spermatocytes (Fig. 19). These are readily distinguished by a marked polarity, such as has been described by most workers on spermatogenesis. The nucleus, now takes up nearly the whole content of the cell and the chromosomes, localized at one end of the nucleus, have retained the same form in which they appeared in the preceding telophase, *i. e.*, as V's. A growth period now sets in which, judging from the great numbers of cells found in this stage and from the complicated processes through which the chromatin passes, must be one of considerable duration. The arm of the V's have already much increased in length, and are no longer congested at one pole, the majority extending across the whole breadth of the nucleus. The apices now touch the membrane at many points (Fig. 20). It is interesting to observe also, that the rate of growth in the several chromosomes varies considerably. Thus Fig. 20 shows three bivalents of full size, while the remaining ones are very little larger than at the beginning of

the growth period. In cells of this small size, it is quite impossible to trace anything corresponding to constant size differences in the chromosomes. Yet it is clear both from the study of the various spermatogonia and the spermatocytes that many gradations actually exist.

A longitudinal splitting of the arms of the V's now makes itself apparent (Fig. 21). Appearing first at the lower end of one of these larger bivalents, the split makes its way upward to the apex, when the other arm becomes involved. Soon most of the chromosomes show the same condition, and it appears very much as though the V's had each split longitudinally along its whole length, the two sister portions remaining united at the apices (Fig. 22). The process is, however, a very gradual one, and all degrees of variation in the time of its occurrence are present. The chromosomes at this point stain much less intensely and are granular. Indeed, the cells in this stage can be most readily distinguished without any closer study by their lightly staining nuclei.

At the completion of the longitudinal splitting (Fig. 22) the chromosomes are at their maximum length. The nucleus is comparatively small and, as a consequence, the individual chromosomes are much crowded and cross and recross each other. This coupled with their granular appearance, and their slight staining capacity, makes it extremely difficult to follow the processes in which they are involved. I have succeeded, however, in finding a considerable number of nuclei in which this crowding is not so marked, and where, in consequence, the more careful study of the individuals was possible. From such cells (Fig. 23), it is quite clear that the chromosomes, now longitudinally split along their entire length, are passing through marked changes. The acute angle of the V's gradually opens out, until at a later period of development, the chromosomes entirely lose their original form, and become pairs of sinuous or nearly straight parallel rods. Fig. 23 shows this process in all its stages (cf. Text-fig. I, p. 13). To the extreme left, a large chromosome shows but a slight opening of the angle, while in the center the very end of the process is already attained, *i. e.*,

where the parallel bivalents have united at both their ends to form a much elongated ring. In Fig. 24 all the chromosomes have opened and the bivalent arms twine around each other several times. Finally Fig. 25 represents a somewhat later stage in which nearly all the chromosomes are in the form of elongated rings. In other cells, the elongated rings may be less frequent (Fig. 26), their place being taken by the bars. These represent the sister bivalents which have not opened out to form a ring after the increase of the angle of the primary V's, but have rather come into more intimate relations with



TEXT-FIG. I.

Diagram of chromatic transformations from synapsis (*a*) to the first maturation division (*g*).

each other. It is important to observe that these bars are, at this stage, about twice as thick as the elongated rings, showing that they are double. What is more convincing, however, is the fact that in some cases the longitudinal split may actually be traced throughout their length. At the same time, the chromosomes have considerably concentrated, so that the changes within the nucleus can now be more easily determined.

From this point onward, the main changes consist in the further concentration of the elongated figures into more perfect rings and thickened double bars. Thus, as in Fig. 27, these two main types, now staining intensely, are found side by side, the double bars, present in the larger number, showing characteristic bendings into thick U-shaped figures.

The spermatocytes are now at the end of the growth period, and the eleven chromosomes distributed around the periphery

are very nearly in the form in which they appear in the ensuing division (Figs. 28–31). The cells are perfectly spherical with the cytoplasm reduced to a very thin ring around the much enlarged nucleus. In the cytoplasm, I have often observed a deep staining granule, throughout the growth period, which very probably is the centrosome. This rapidly divides, the nucleus elongates and the prophase of the first maturation division is attained. The types of chromosomes, viz., the rings of various form and the double elongated bars are at this stage found lying irregularly over the whole spindle (Figs. 32–34). From these figures, two important conditions are clearly presented. In the first place, the longitudinal split shows distinctly in many of the bars running throughout their length especially in Fig. 34 and second, the several chromosomes, both bars and rings, present remarkable size differences, some being as much as three or four times the bulk of others.

The chromosomes now move uniformly into the equatorial plate, giving in the metaphase pictures of striking clearness (Figs. 35–40). There are at this point fewer rings in proportion to the bars and these that still pèrsist are much more slender, showing that they are being converted, through elongation, into the chromosomes of the other type. Finally, in a considerable number of spindles, obviously of a later metaphase, the bars alone exist and the time for division is at hand (Fig. 41). It is hardly necessary, at this point, to discuss the nature of this division process. From the evidence presented, it has been fully demonstrated, first, that the bar and ring-figures are structurally tetrads, *i. e.*, composed of four portions, *a*, *b*, *a*, *b*, each of which is a quadrant (Text-fig. I, *f* and *g*), and second, that the split running in the long axis of the figures is a longitudinal one separating the sister bivalents. The extremities of the figures are then the longitudinal ends, while those intermediate between these, are the points of synapsis. It is obvious that the long axis of the bars lies in the long axis of the spindle, and that the points of synapsis are in the plane of the division. This division is, therefore, transverse or reducing. On this point there can be no room for doubt.

The spindles elongate, and the bars are drawn out across the equator, a thin strand connecting the dyads. This soon disappears, leaving the halves as thicker, almost spherical bodies drawn out to an end in the direction of the division plane (Figs. 41–42). While this is the usual form, in some instances, other structures are presented in which the true double nature of the bodies is more distinctly brought out. Thus, as in Fig. 43, one of the dyads is a short **U**. This is evidently a case where the transverse division occurred before the ring had elongated sufficiently into a bar. The dyads move to the poles, and the first division is at an end (Figs. 44–46). Here the chromosomes are densely crowded together, and in the late telophase (Fig. 46) the study of the individual chromosomes is quite impossible.

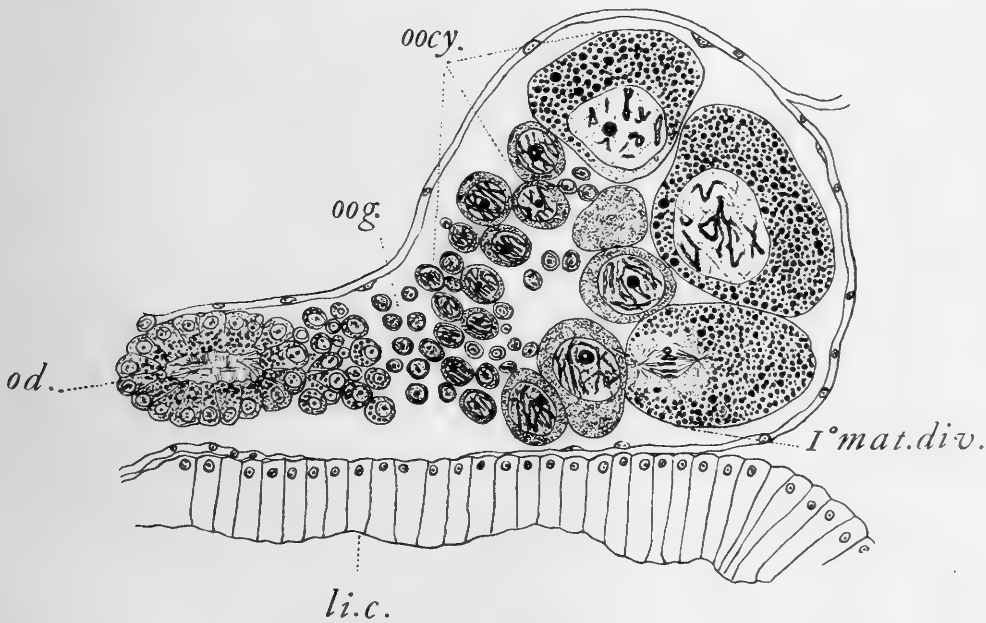
Judging from the rarity of its occurrence in the testis, this stage is one of short duration. The second maturation figures (Figs. 47–54) are about one half the size of those of the preceding division and are at this early period of a spindle shape. The chromosomes appear as the reduced number of rods or bars, showing a distinct constriction in the middle, and have arisen by the further concentration of the dyads, very probably during the last telophase. In a cross section of the spindle in the metaphase (Fig. 48) the eleven rods are even more distinctly seen. These lie in the spindles that the constrictions are in the plane of division. The chromosomes are therefore so directed that this division is longitudinal, separating the sister monads which had arisen by the splitting of the arms of the primary V's in the early periods of spermatocytic growth. In the early anaphase, the two halves of the rods begin to move apart, leaving a thin strand of chromatic substance between (Fig. 49). At the same time, the monads still further condense, and with the complete division, in the middle anaphase, give the appearance of small spheres (Figs. 50–52), the chromosomes dividing quite synchronously. In the telophase (Fig. 53) the spherules have arrived at the poles, but do not as yet show any sign of fusing into one mass. This does not occur until a somewhat later period (Fig. 54) when the cytoplasm shows the characteristic constriction separating the two resulting spermatids.

After the separation of the sister spermatids, a resting period of considerable length occurs. The chromatin aggregated into one spherical mass at the telophase, loses in staining capacity and breaks up into small granules which extend throughout the nucleus (Fig. 55). These granules may be of all sizes, and evidently represent the different stages in the successive breaking down of the large mass into its components. The nearly spherical cells now begin to elongate along one axis, and the chromatin definitely localizes itself into two masses at two opposite points along the axis of elongation, leaving only a few scattered granules in the center (Fig. 56). In Fig. 57 the anterior end of the head is clearly to be distinguished from the posterior one. The former is drawn out to a point into which the chromatin is very densely crowded; the latter is much rounder and shows distinctly an end knob which, already existing in the preceding stage, is the beginning of the formation of the middle piece. Between the two ends the chromatin granules have come together more closely (Figs. 57–58) and now form a third deeply staining area (Fig. 59). With the further elongation, the chromatin masses, before and behind, are pushed out in the direction of the central strip with which they finally come into contact. The chromatin is thus made continuous throughout the head, although open spaces may still be made out (Fig. 60). In the meantime the tail is increased in length, and the whole structure takes on the appearance of the matured spermatozoön. The spaces soon fill up, and the head, now homogeneous, has reached the end of its development. The middle piece however, is still of considerable breadth, nor has the tail anything like its final form. These two structures stand in a reciprocal relation to each other. What the middle piece loses in size, shows in its increased length of the tail. This process continues until the former is reduced to a small deeply staining knob behind the head. In the final changes, not even this persists, for in the great majority of cases the middle piece and head fuse closely together, leaving not even a slight constriction to indicate the former independence of the two. The mature sperm is thus a composite of two distinct portions, — a

head (which is itself compound), and a long whip-like tail. The latter is about three times as long as the head and becomes continually narrower as it runs to its end (Fig. 61).

IV. Oögenesis.

A median longitudinal section of a fairly large female polyp often shows, in some one view, the completely developed ovary with all the stages of egg development, through the oögonia and the growing oöcytes to the maturing ova (Text-fig. II). This structure, situated in the space between the so-called



Text-fig. II.

Longitudinal section of ovary showing the various shapes in development of egg. *od*, oviduct; *oog.*, oögonia, *oocy.*, oöcytes; *li.c.*, liver-cells.

"liver-cells" below, and the floor of the atrium above, is like the testis, bilaterally symmetrical, each half being a pear-shaped organ, the narrow end of which is at the center of the polyp in connection with the oviduct, and widening as it extends outward to the side of the body. In view of Ehlers', '90, comprehensive description of this organ, it is unnecessary here to go into further details of structure, except to note that as the full grown eggs near the periphery become matured, they move back toward the

center of the ovary and finally pass through the oviduct into the brood-pouch formed in the lower portion of the atrium.

As in the *Copepod* ovary, a continuous line of development of the germ-cells can be traced from the center outward. We accordingly find nearest the oviduct the smallest primary germ-cells, which have persisted unchanged from the early stages of the polyp. In these, division figures are never observed, except in the youngest individuals. It may, therefore, be inferred that the cells do not develop simultaneously. The nuclei, which take up the greater part of the cell, are in the resting stage, the chromatin being widely distributed in the form of a reticulum. There are also at opposite ends of the nucleus two small nucleoli which often move toward the center and fuse into one larger and more irregular body. Altogether these cells are comparable to those described by Häcker, '95, in the ovary of *Canthocamptus* as the primitive egg cells (*Ureizellen*), and as this author states, "are to be considered as the direct descendants of the primary germ-cells of the embryo, and through active, apparently periodic, divisions, give rise to the elements of the ovary."

Next in order come the oögonia (Text-fig. II, *oog.*). These, as in other forms, pass through several generations and division-figures are common both in young and in older ovaries. Disregarding for the moment the last generation of oögonia (more fully described below), the other generations are in the main very much alike with but slight differences in size, the cells becoming smaller with the successive divisions, although there is a considerable growth period between these. The divisions of these oögonia are important for a comparison with the subsequent processes. Fig. 62 shows a cross-section of a metaphase of an early generation. The chromosomes are as was observed in the early spermatogonia slender, distinctly V-shaped bodies, with the angle toward the spindle. Fig. 63 shows a longitudinal section through a similar spindle. The 22 chromosomes are here again V-shaped, and as such, they move toward their two respective centers where they concentrate into a very compact deep staining mass (Fig. 64).

The most important of the oögonial divisions is, however,

what I believe to be the final one, difficult as it is to prove it to be such by indirect evidence. Owing to the rapidity with which this division is passed through, I am able to describe only the metaphase and the late telophase. Yet these two stages are sufficient, I believe, to show that here again, it is in the process of the last division that the true reduction in the number of chromosomes takes place. In the cross-section of the metaphase, Fig. 65, the chromosomes are almost without exception no longer the characteristic V's of the preceding oögonial generation but rods. Although I am unable to describe the nature of this transformation in the egg save by analogy of what was seen in the sperm, there can be no doubt that this marked transformation has actually occurred. The number of chromosomes is still unreduced, 22, and from the comparatively small size of the cell, the stage most probably represents the last generation. It is in the telophase of this generation, however, that the contrast with the like phase of the earlier generations is most striking (Fig. 66). The chromosomes, in this preparation, are very fortunately not crowded into one dense mass and may therefore be studied individually. Such a study shows that in both of the daughter cells the number of the V-shaped chromosomes is no longer that of the foregoing metaphase, but is reduced to about eleven. It is important to observe also, that these figures differ from those of the preceding generations, showing in some cases, deeply staining knobs at the apices. From both these latter considerations, it appears with much probability that these eleven V's are each bivalvent and represent single chromosomes united end to end.

This evidence in *Pedicellina* is strengthened by a comparison of the somatic divisions. The chromosomes are in all cell-generations V-shaped, sometimes appearing in the form of temporary rings in the prophases and metaphase. Anticipating the fuller description of the somatic divisions, Figs. 107–109, Pl. III, show clearly the presence of V's, rings and double V's in the metaphase, and single V's in the anaphase of the first somatic division. This same type of cleavage has been

traced to a late stage in the development of the embryo, and in every case where the individual chromosomes could be studied they appeared in a form quite like that found in the earlier cleavages. The same condition prevails in the divisions of the tissue cells. An instructive comparison can here be made. Fig. 103, Pl. III, shows a cross section through a "liver cell" in the metaphase. Both the cell and the chromosomes are remarkably like what was found in corresponding division figure of the early oögonium (Figs. 62–63). The chromosomes are all distinct V's, and are turned toward the spindle. These split longitudinally and are in the late anaphase, and finally in the telophase, still V's (Fig. 104, Pl. III). Here they are of about the same size and form as those observed in the last oögonial telophase (synapsis) (Fig. 66) but in the former case the number is very clearly double that in the latter.

Returning to the ovogenesis, it must be admitted that the evidence is not as complete in the egg as it was in the sperm; yet there can be but little doubt that the reduction is here attained in a like manner, *i. e.*, by an end to end conjugation of the individual chromosomes in the last oögonial telophase. There is then, at the very beginning of the oöcytic period, a known constitution of the chromatin, making possible a proper interpretation of the processes which now ensue.

The newly formed oöcytes are now easily distinguished and, in every regard, but size, resemble the youngest spermatocytes. The chromosomes show the same polarity and the nucleus is situated in like manner in reference to the cytoplasm (Figs. 67–69). Occasionally one or even two of the chromosomes move away from the rest to the other end of the nucleus, but as a rule, the apices are all directed away from the plane of the last division, *i. e.*, from the *central* end of the cell (Montgomery, '99). At this, the earliest period of oöcytic growth, the angles of the V's are large. One may however observe an occasional crossing of the distal arms to form loop-shaped figures (Figs. 70–71), but to this little significance can be attached. There is, at every point, confirmation of Montgomery's contention that the arms of the bivalent chromosomes are not sister-

chromosomes which have arisen through a longitudinal split, and have remained attached at one end, but rather that these represent the univalent chromosomes which united at the last oögonial telophase.

As will appear from a closer examination of the figures there are at the apices of the V's, in a great number of cases, the deep staining knobs (Figs. 67, 69, 70) which were described at the same point in the V's of the late synaptic telophase (Fig. 66). Since that period the only new element that has appeared is the nuclear membrane of the reconstructed nucleus. The chromosomes have preserved not only their characteristic form, but their position as well. The presence of these synaptic knobs cannot by any possibility be interpreted as chance thickenings along the chromosomes; the constancy of their location and the frequency of their occurrence point very strongly to the conclusion that they represent the points of union of the univalent rods, and as such, they would correspond to the linin fibers connecting the two arms at the apices of the V's, as described by Montgomery, first for *Peripatus*, '99, and later for the Amphibian spermatocyte, '03.

As the growth period begins, the cytoplasm becomes easily distinguishable in contrast with the previous stage, and the chromosomes, moved away from the one end of the nucleus, now lie apposed on nearly all sides to the nuclear membrane (Figs. 71–72). There is as yet no sign of granulation of the chromosomes. It is usually, also, at about this time (although there is much variation in this regard) that a longitudinal split in the arms of the V's makes its appearance (Figs. 73–74). The splitting often begins at one end of an arm and passes upward toward the point of synapsis, though in many cases the early splitting may occur in both arms at the same time (Fig. 75). Fig. 76 shows a little later stage where most of the chromosomes are already divided and have begun to show a distinctly granular appearance. This process, too, is extremely variable in the time of its occurrence, and is not necessarily connected with the longitudinal split, which, in most cases, takes place before the granulation has begun. This is impor-

tant, because from the works of several authors, it would appear that there was such a connection, and that the granules first formed and divided each longitudinally to form the beaded sister-arms.

The chromosomes have taken part in the growth so characteristic of both cytoplasm and nucleus. As in *Canthocamptus* and the *Copepods* generally, there is no period of rest nor is there a true chromatin-reticulum formed. The individual chromosomes persist as such from the last oögonial telophase, through the growth period of the oöcyte into the maturation-spindle, where they become the tetrads and rings to be described later. Nor is there at any stage during the egg growth, a continuous spireme. In this regard *Pedicellina* is unlike such forms as the *Copepods* and some other Crustacea, and resembles the spermatocytes of *Peripatus*, *Brachystola* (Sutton), and *Anasa* (Paulmier, '99). There is, therefore, no possibility of the formation of the bivalent chromosomes by the transverse division of a continuous chromatin thread, as has been described in the former of the above groups. The formation of a continuous spireme appears even in these forms to be but a secondary process, which may or may not occur, and as Häcker, '97, points out, there is even in the same species a great amount of variation in the time of its segmentation.

The cytoplasm has by this time increased in amount, and the cells now have the characteristic appearance of oöcytes (Fig. 77). The chromosomes show no order in their distribution, and cross and intertwine among themselves. They have also become extremely granular and ragged at this point, and in some cases show distinct breaks in their course, making it often difficult to follow the individual bivalents throughout. It is then that the linin-reticulum in which the chromosomes are suspended is most clearly visible. This new element has now become of considerable importance. In the early stages of growth there was next to nothing of the reticulum to be seen. As the nucleus grows, it comes more and more into view, until finally it appears much like a web, crossing the nucleus at all points and serving as a support for the chromosome. With

Heidenhain's hæmatoxylin it can be made to stain intensely, so that at times it becomes impossible to distinguish the chromosomes with which it is connected. On continuous extraction, however, this difficulty can be readily overcome, and finally nothing but the deep staining granular chromosomes remain in view, with but the slightest trace of the linin, — sufficient only to show the true relation existing between the former and the latter.

Up to this point the development of the egg and the spermatozoön has followed, very closely, along the same lines. In the several generations and nature of the oögonia and spermatogonia; in the presence of the V's in the last oögonial and spermatogonial telophase, with its consequent reduction of the chromosomal number; in the further history of the bivalent V's thus formed; their lengthening, their irregular distribution within the nucleus, and finally in the longitudinal splitting of their arms, the early male and female germ cells are quite alike. It is now necessary to trace those processes which from this point onward, transform the longitudinally split bivalents into the characteristic figures of the first maturation-division, and to compare them with the corresponding changes in the sperm.

The chromosomes, now longitudilly split along their entire length, begin to show very characteristic changes. As in the sperm, the acute angle of the V's gradually opens out, until, at a later period of development, it becomes equal to 180° and the chromosomes become nearly straight longitudinally split bodies (Figs. 78–79). In this movement the arms swing each around the apex of the V (the point of synapsis). This process does not occur at any fixed time, nor do all the chromosomes act together in this regard. In the end, however, the changes in all are quite alike. The chromosomes move toward the periphery of the nucleus, Fig. 79, where they lie below the nuclear membrane, in the form of almost straight longitudinally split threads. We are here again reminded of the observations in the eggs of the *Copepods*, where Rückert, '94, and Häcker, '92 and '95, found the same conditions of the chromosomes (cf. Figs.

7a and *7b*, Pl. XXII) of Rückert's memoir, "Zur Eireifung bei Copepoden."

The sister threads of a bivalent chromosome, now fully extended, may secondarily unite at one of these free ends and in this way give rise to a new long-armed V (Figs. 80–81). This figure must not, however, be confused with those observed before the opening up of the angle of the synaptic structures. The arms of the early V's are each longitudinally split, of which condition there is not a trace in the later ones; and secondly, while the arms of the former are univalent chromosomes which have united in synapsis, those of the latter are bivalent sister chromosomes which have become secondarily apposed at one end. The middle point of the long arms of the second V's, therefore, corresponds to the apices of the V's in the first (cf. Text-fig. I, p. 13). In the greater number of cases the sister bivalent chromosomes do not unite at one point alone, but often twine around each other, thus forming 8's and loops of many types; in all, however, the same homologies pointed out above must hold (Figs. 82–84).

The chromosomes, having lost somewhat in their staining capacity during the last period, again increase in this regard and lose at the same time their ragged appearance. The linin, staining very lightly, forms a fine meshwork over which the chromosomes appear distributed, very different from the deep staining reticulum of the earlier stages. The chromosomes are in all stages of concentration and vary greatly in size (Fig. 84). In general, the ensuing process may be summarized as follows: The two sister threads unite at one of their ends, if they have not at some earlier stage already done so, and then the second or the free ends come into contact, forming a ring. Or the arms may first cross and then unite at the ends; in this way are obtained, I believe, the very common 8-shaped figures (Figs. 84–85). In other cases the second pair of free ends may fail to unite, but come close together, thus forming two thick bars in the form of a V. Finally (and this, as the figures show, is of very frequent occurrence) the bivalents may fuse along their whole length, forming long rods of considerable thickness.

The longitudinal split is in these most often completely obscured, but I have been able, in a considerable number of cases, to discern it at several points along the course of the fusion (Fig. 84). These rods rarely remain extended, but band into a variety of figures such as S's and shallow U's. In the meantime, the chromosomes as a whole have much concentrated and are now not much longer than when they appear in the early prophase of the first maturation mitosis.

Fig. 85 shows such a prophase. The single centrosome and aster have already made their appearance The chromosomes are all very much concentrated and are in just the form in which many appear in the metaphase of the following division. We observe here all the main types pointed out in the discussion of the earlier prophases. There are thus the rings of various forms and the much contracted bars. These are in most cases of dumb-bell shape, showing a constriction in the middle and in some cases a distinct longitudinal split. The chromosome to the extreme left is of particular significance, in that it points out that the rods are also formed by the secondary elongation of the rings along one axis. In this particular instance, the upper portion of the chromosome is already of bar form, while the lower has as yet the form of a ring with the space showing very distinctly. This accessory formation of thick rods from rings is, I believe, of constant occurrence at this period.

Figs. 86–87 are early prophases and represent the two main types of chromosome form in the first maturation. Thus, lying side by side, irregularly distributed over the whole spindle, are on the one hand the rings, more or less contracted, and on the other, the bars, somewhat shorter and thicker than before, most of them bent at the middle to form the figure ⌣. This bending in *Pedicellina* is comparable with the similar changes observed by Paulmier, '99, in *Anasa*, Griffin, '99, in *Thalassema*, and more recently by Sutton, '02, in *Brachystola*. In these objects, this secondary bending is often complete, thus forming a ring which is split along its whole course. I have not, however, observed any such process in *Pedicellina*, where the bending is never much more advanced than to form a semi-circle.

The chromosomes are now drawn more uniformly into the equatorial plate, but there is a considerable amount of variation in the development of the spindles at this stage. Thus, while as in Fig. 88 the nuclear membrane still persists and the spindle has not yet reached its maximum length, in Fig. 89, in contrast, although the chromosomes are not as fully drawn into the equator, yet the spindle is in its final form. It is such stages as these that make possible a confusion with the later anaphases. The shortened and bent bars, distributed on both sides of the center, often give the appearance of dyads which might have arisen by the cross division of the rings. Careful count of the total number of chromosomes has, however, always given the reduced number, and this, together with the fact that the spindles have not as yet moved to the periphery, has convinced me that the bars are not dyads but the same structures observed in the immediately preceding prophases. It is at this point, too, that the cross-chromosomes make their appearance. These, in some instances, show an open space at the center. The arms are of unequal size, and the larger lies in the long axis of the spindles. These considerations would tend to show that these figures had arisen, like those described by Griffin, '99, in *Thalassema* and *Zirphæa*, from double bars which had extended out from the middle or more probably as Conklin, '02, suggests, in his work on *Crepidula*, by the flowing out of the substance of the rings. In any case, it is hardly possible that the arms represent dyads which have prematurely separated and then rotated on each other.

The spindle, as a whole, moves toward the periphery and the metaphase of the first maturation division is attained (Figs. 90–94). The chromosomes elongate at the same time, and the ring chromosomes of various form are now also observed as thick rods in which the longitudinal split is more or less distinct. In spite of the former diversity, there is at this stage a remarkable uniformity in the appearance of the chromosomes. We may also, at this point, decide upon the nature of this division. It will be necessary, for this purpose, to review briefly the history of the chromosomes (cf. Text-fig. I, p. 13). It was

pointed out in the discussion of the early prophases that the bivalents appeared, first, as elongated bars with a split running the length of the bar and, second, as rings of various forms. The latter, in their further development, are often converted into bars of the first type or into cross-shaped figures ; but in both of the two main types, whatever be the individual peculiarities, it is clearly seen, in the light of the earlier stages of oöcytic growth, that the space running along the long axis of the figure is the longitudinal split separating sister bivalents. The ends of the bars would then be the longitudinal ends and the points intermediate at the middle on the sister bivalents would thus be the points of synapsis. A division, therefore, which passes through the former points would be longitudinal, while one passing through the latter would be transverse or reducing.

In *Pedicellina*, it is quite evident that the second of these conditions is the actual one. In every instance of the considerable number of late prophases and metaphases examined, I have found the rods so placed that their long axis corresponded with that of the spindle. The points of synapsis are, therefore, in the equator and the division which now ensues passes through these points, and separates the univalent chromosomes which had remained united since the last oögonial telophase. In this regard, the conditions in *Pedicellina* agree with the early observations of Henking, '90, on *Pyrrochoris*, Paulmier, '99, on *Anasa* and those of Montgomery, who in *Peripatus* and a large number of other forms, always found the first the reducing division. On the other hand, these results are opposed to the conclusions of Rückert, '94, and Häcker, '95, and '02, on the *Copepods*, of VomRath, '92, on *Gryllotalpa*, of Griffin, '99, on *Thalassema*, and the more recent ones of Sutton, '02, on *Brachystola*, according to whom the first division is longitudinal.

The dyads resulting from the first division are, in the main, of one form in the early anaphase as were the tetrads in the metaphase. As Fig. 95, *a* and *b*, shows, there is often present a thin strand of chromosomal substance connecting the dyads across the center, but this soon disappears. In no case have I

been able to make out the longitudinal split in these dyads, which undoubtedly exists. In the excessive elongation of the structures during the division process the two sister portions have simply come into more intimate relation, thus giving to the products of the division the appearance of homogeneous knobs drawn out into a blunt end in the direction of the equator.

Owing very probably to the rapidity with which the later stages of this division are passed through, I have not found among my many preparations any stages between these anaphases and the late telophases. By this time the spindle has advanced even further toward the periphery, and the first polar body is extruded. This structure is a comparatively large sphere in which lie the eleven chromosomes, now much concentrated. At this stage these may be quadrupartite, spherical, or even rod-like in structure, showing in this last instance a very distinct constriction at the middle. This, preserved plainly in the chromosomes of this form, represents the points of union of the sister univalents which had arisen through the longitudinal split in the early growth stages. As these chromosomes later move apart in preparation for the division of the first polar body, they show clearly bands of linin connecting them throughout. In striking contrast with the egg, also, the polar body is of pure cytoplasmic substance in which no yolk spheres are to be found.

The first division completed, the chromosomes within the egg very probably persist individually in the telophase without forming a resting nucleus. The centrosome and aster also divide very rapidly, forming the beginnings of a new spindle, the long axis of which is at first 90° to that of the preceding one (Fig. 96). The chromosomes are distributed irregularly over the whole of one side of the spindle, and are of the same form as just described for their sister chromosomes of the first polar body. In addition, however, there are also present a few of distinctly U shape, the arms of which are rather close together. The bend of the U would, in these, correspond to the constrictions at the middle points of the bar shaped chromo-

somes. Altogether, there can be little doubt that these bodies represent the knobs of the anaphase of the preceding division in which the longitudinal split has reappeared, separating the two sister univalent portions. It is also of interest to observe in one arm of the clearest of these U's a constriction at the middle point. This corresponds to the secondary constrictions along the univalent arms, which give rise to the quadrupartite bodies, but here the processes are somewhat dissociated.

The spindle now rotates into a radial position (Fig. 97) with the chromosomes more nearly in the equator. In this figure, the chromosomes are cubical and thick rod-like bodies, and in this regard agree in part with what was described by Conklin, '02, for *Crepidula*. It must not be inferred, however, that the quadrupartite appearance of some, is an expression of the real constitution of the bodies. The secondary pair of indentations never cut deeply into the chromosomes and may be entirely absent, leaving only the constrictions of the longitudinal split and from what is known of the past history of the dyads, they are probably of little significance in the interpretation of the division in which they occur. The spindle now elongates considerably and moves to the periphery (Fig. 98). The chromosomes bear the same relations to the spindle that was observed in the slightly earlier stage of the preceding figure; for here, too, the longitudinal constrictions, wherever they clearly occur, are to be observed in the plane of division. The division process which now follows passes through these points and the second maturation is therefore longitudinal or equational. In the middle anaphase (Fig. 99) the monads appear as small, deeply staining spherules. As far as can be determined, they are smaller than the chromosomes of the late prophase and in the great number of instances are about one half as large as the latter. There is, however, a considerable amount of variation in the size of the individual chromosomes which makes such an estimate of size relations very difficult. In the telophase, the chromosomes (Fig. 100), show no change in form of any significance, and are now aggregated around their respective poles, the centers of which are almost entirely faded out. As

in the first polar body formation, a cap of pure cytoplasm appears at the periphery (Fig. 101) and into this the peripheral chromosomes move to form the second polar body.

In the meanwhile, the first polar body has divided. This, in *Pedicellina*, as in most other forms, *Thalassema* (Griffin), *Limax* (Mark), etc., is a very common occurrence and is accomplished by mitosis (Fig. 102). The chromosomes, of the same size and form as those observed in the second maturation division, are so placed in the spindle, that they are divided longitudinally like the other bivalents in the egg. In the metaphase, a deep constriction occurs on both sides of the polar body which leads to complete division. From the many cases of second maturation spindles observed, it appears that the division of the first polar body is accomplished very early; indeed, is completed by the time the second maturation division within the egg has reached its metaphase.

A brief account of the cytoplasmic changes of the growing egg may be appended. In the very youngest oöcytes, after the synaptic phase, the cytoplasm is but barely visible as a thin layer around the newly reconstructed nuclear membrane. This rapidly increases, especially at the pole opposite that of chromatin concentration. Thus arises a cytoplasmic polarity characteristic of the oöcyte during the whole growth period. The structure of the cytoplasm of the sublimate fixed material appears as a mesh-work of fine microsomes or granules which are imbedded in a continuous substratum. Later, a new element makes its appearance in the form of large yolk granules which arise at first on the periphery of the cell as deeply staining spheres of various sizes, and increase in numbers by the formation of successive layers inward toward the nucleus. I am unable to decide whether the yolk masses arise in situ or actually move inward from the periphery where they are formed.

Of the considerable number of oöcytes which begin their development, only a portion reach maturity; the remainder are converted into nutritive cells. These may be distinguished very early. Within the nucleus constant and distinct differences may be observed. The chromatin is not in the form of distinct chro-

mosomes and stains rather lightly in comparison with that of the true oöcytes.

V. Fertilization and Cleavage.

The ripe spermatozoa cast out into the water make their way into the atrium of a female polyp, thence into the ovary, where the eggs are fertilized. Spermatozoa are often found a considerable distance within eggs where the chromatin is still long before concentration (Fig. 80, Pl. II, sp.). In most cases, however, fertilization occurs when the first polar spindle is about to be formed. With the latter in the metaphase, the fertilized egg makes its way through the oviduct, into the atrium, where the brood pouch is formed. Here the remainder of embryonic development is passed through until the free swimming larva is attained.

In the act of fertilization, the head alone enters the egg (Fig. 80). The head, however, as was shown in the preceding section, is a composite structure, containing at its posterior end the middle piece with which it had fused. From the comparison of many instances, it appears that the sperm may enter the egg at any point. Once within, it makes its way through a mass of yolk spheres, leaving behind it a track of pure cytoplasmic substance. It is in this area that the sperm-aster with its centrosome and centriole lie. The head now concentrates to an even smaller size, losing at the same time, its lanceolate form and giving very much the appearance of one of the yolk spheres among which it lies. The astral system is no longer to be observed.

In the meantime the maturation processes are being passed through. With these at an end, the sperm head swells up and soon becomes of equal size with the female pronucleus from which it can at this time be distinguished only by the proximity of the latter to the newly formed polar bodies (Fig. 106). Within both, the chromatin is often in the form of a finely divided reticulum supported and connected throughout by a continuous linin system. As the nuclei approach each other they grow larger and the chromatin reticulum concentrates into

definite chromosomes. At first crowded together they soon move apart, and appear in the reduced number in each in the form of deeply staining 8- and V-shaped figures and even as more or less straight rods. With the pronuclei apposed, the membrane between them grows much fainter; the chromatin within both, however, remaining quite distinct throughout. I have not been able, in spite of the many cases studied, to discover any achromatic structures in the vicinity of the pronuclei. At any rate, the first somatic spindle is very rapidly formed, and, in the late prophase, the normal number of chromosomes is clearly present. These are (Fig. 107) nearly all V's. In the metaphase Fig. 108, they are longitudinally split, the sister portions resulting, often remaining united at the ends, to give the appearance of the heterotypic ring. In the anaphase (Fig. 109) the same V-form of the chromosomes is preserved and the first somatic division is brought to a close.

VI. Comment.

At the present time, a very striking convergence of opinion regarding the nature of the maturation processes is replacing the wide differences which have until recently existed. The view first clearly pointed out by Boveri, '91, that the true solution of this problem is to be sought, not in the actual maturation divisions but long before these, in the processes occurring in the antepenultimate generation of cells (primary oöcytes and spermatocytes) has received remarkable confirmation in the recent works of Montgomery and Sutton among the zoölogists, and in those of Rosenberg, Farmer and Moore, Gregoire and Berghs and finally Strasburger among the botanists. To Montgomery especially is due the credit for having shown that the key to the problem is to be sought in the so-called "Synapsis-stage" and that the beginnings of synapsis lie even further back than the stage so designated by Moore ('95) — *i. e.*, in the closing phases of the last oögonial and spermatogonial division. Even greater interest has been centered in this stage through the remarkable conclusions of the above-mentioned zoölogists, that at this period a pair-wise conjugation of corre-

sponding or homologous maternal and paternal chromosomes occurs; for, as Sutton has pointed out, this phenomenon, if it really occurs, gives the basis for a probable explanation of the Mendelian phenomena of heredity.

In *Pedicellina*, the phenomena are such as to give no evidence as to whether such conjugation of paternal and maternal elements occurs, yet the facts give good ground for supporting the more general conclusion that a union of chromosomes, two by two, takes place at this period. In this way are produced the bivalents of the long growth period, giving almost decisive proof of the validity of Häcker's early interpretation of the chromosomes in the post-synaptic stages. If this be granted there can be no escape from the conclusion, in the light of the succeeding processes, that one of the maturation divisions is transverse, separating pairs of identical (sister) chromosomes. It is now well to review in greater detail, the various phases of the development of both the egg and the sperm cells to see more clearly the grounds for this accordance with the results of the above.

(*A*) "*The Individuality of the Chromosomes.*"

This hypothesis has recently received strong confirmation at the hands of students of insect spermatogenesis (McClung, Montgomery, Sutton, etc.). Not only have these authors observed constant size differences in the chromosomes, but in the case of certain peculiar elements, the so-called accessory chromosomes, the persistence of the structures as such has been traced throughout several generations of spermatogonia, the two spermatocyte divisions and finally into the spermatids. This is fully in harmony with the experimental results of Boveri, who, in his remarkable paper on "Multi-polar Mitoses" ('02) was able to conclude "dass nur eine bestimmte Kombination von Chromosomen, wahrscheinlich nur die Gesamtheit der in jedem Vorkern enthaltenen, das ganze Wesen der Organismenform, soweit dasselbe vom Kern aus bestimmt wird, repräsentiert." and "dass nicht eine bestimmte Zahl, sondern eine bestimmte Kombination von Chromosomen zur norma-

len Entwickelung notwendig ist, und dieses bedeutet nichts anderes, als dass die einzelnen Chromosomen verschiedene Qualitäten besitzen müssen."

In *Pedicellina* throughout the long period of growth, from the prophases of the last generation of oögonia and spermatogonia through the maturation divisions, the chromosomes persist as definite and distinct structures, and this in spite of the great increase and subsequent condensation of the chromatin mass, in many regards as marked as Rückert, '92, found in *Pristiurus.* At no point is there any such marked disintegration of the chromatin thread or any crowding together into one deeply staining mass, as would make difficult the minute study of the individuals. Nor is there any relation to the nucleolus such as might throw uncertainty on the constitution of the chromosomes. While the latter, in their condensation, may give off certain cleavage products to the substance of the egg nucleolus, at no point have I found any evidence for the possibility of the reversal of the process. In one more regard, the conditions are significant. The several chromosomes in the young oöcytes and spermatocytes vary considerably in size, some being fully three times as large as others. Though I am unable to determine any constancy in this relation of certain definite chromosomes to each other, as Sutton could in *Brachystola*, yet this proportionate diversity is obvious throughout the growth period and most clear in the metaphase of the first and second maturation divisions.

(*B*) *Reduction.*

As has been already remarked, it is in the matter of reduction that the most significant results of this paper were obtained. Throughout the entire life cycle of somatic divisions the chromosomes appear always in the form of V's and occur in exactly this form, in the several earlier generations of oögonia and spermatogonia. In the last generation, however, my evidence shows unmistakably both in the egg and sperm that a new type of chromosome makes its appearance in the form of dumb-bell shaped rods in which the angle of the previous V is almost completely undone, the constriction in the middle of the straight

rods very probably corresponding to the apices of the V. These new structures divide, preserve their rod-like form in the anaphases (my evidence is complete for the sperm only, on this point), and finally, in the telophases of both oögonia and spermatogonia give rise to the reduced number of bivalents. What can be the significance of this sudden change in the character of the chromosomes of the last division? In the light of the evidence here adduced, and of that from the other sources already referred to, it is almost impossible to avoid the conclusion that the change is a direct preparation for the process of reduction. Were the V's present in this last division also, twenty-two V-shaped chromosomes would be found at the poles in the telophase, instead of the eleven actually found. Under such conditions, the appearance of the V's in the post-synaptic phases of the early oöcytes and spermatocytes, even if reduced in number, would throw no light on the character of the reduction process. For, in such a case, the reduction might have been attained in any one of a number of ways; for example, by the superposition and fusion of the V's two by two, as some authors actually conjecture to be the case. But in *Pedicellina*, the true conditions are distinctly otherwise. The V's are not present in the latter half of the last division process and appear as such only later in the telophases as new formations and clearly reduced in number.

Without undertaking a review of the already enormous literature on this period in the development of the germ cells, it is here necessary only to point out that the "synapsis-stage" has been observed in nearly every form in which the early processes of development have been studied. Thus, in such diverse types of spermatogenesis and oögenesis as have been described for the *Amphibia*, on the one hand, and the *Copepods* on the other, the close aggregation at one pole of the nucleus regularly occurs. First designated by the appropriate term "Synapsis" by Moore, '95, this author laid the basis for all later progress in this subject by associating this stage with the process of reduction. To Montgomery, however, we owe the interpretation of synapsis in the form here adopted. Commenting on the occasional

appearance of V's in the anaphase of the last spermatogonial division of *Peripatus*, '99, he says, "This V-shaped approximation of the chromosomes into pairs is more than a mere coincidence due to the crowding together of the chromosomes; it is, I think, the first sign of the pairwise union of chromosomes by which the reduction of their number is effected and which results in the formation of bivalent chromosomes." But this V-formation is, as he himself states, unusual at this point. That, coupled with the fact that there intervenes between this and the next appearance of the V's, a stage in which the chromatin is closely packed into one dark staining mass, and that the individual chromosomes cannot, with any distinctness, be made out, throws some uncertainty on the result. In *Pedicellina*, on the contrary, it is no difficult matter to so stain the young oögonia and spermatogonia that at no stage do the chromosomes form a close undecipherable mass. Thus Figs. 17–18 and 66 show that while the chromosomes do group together, yet it is very apparent that the individual chromosomes are in the form of V's, of which there are about eleven. The main difficulty observed in the evidence from *Peripatus* is thus overcome.

Strong support to Montgomery's interpretation is given by Sutton's observations on *Brachystola*, '01, '02 and '03. This author observed constant size-differences in the spermatogonial chromosomes and that these, with the exception of the single accessory chromosome, were paired as regards size. This condition persists throughout the eight successive generations of spermatogonia, but is lost in the transition into spermatocytes, in which the reduced number of chromosomes appears, but with the same size-differences between the now bivalent chromosomes that were so characteristic of the pairs of chromosomes in the spermatogonia. "These spiremes" (the reduced number), he writes, "are graded as to size, just as were the chromosome pairs of the spermatogonia." Further, ". . . a division may be noted separating the spireme into two distinct limbs of approximately equal size, which are frequently doubled on each other at the point of union." It is on this evidence alone very difficult to disagree with Sutton that in the tetrads which later

form, "the transverse marking separates two spermatogonial chromosomes which have conjugated end to end in synapsis."

Of very considerable interest in this connection is the still more recent work of Miss Stevens, '03, on the spermatogenesis of *Sagitta*. This author, on good evidence, also decides for synaptic-reduction. Thus: "Two types of spermatogonial divisions are found . . . ; one in which the daughter chromosomes appear at the poles of the spindle as 18 rods . . . ; and another type, where a much smaller number of loops, probably nine, are found at each pole. . . . These figures lead me to think that the so-called synapsis stage occurs in *Sagitta* at the close of the final spermatogonial division, the chromosomes uniting in pairs at the poles of the spindle. There is so much variation in the size of the spermatogonia, that it is impossible to be absolutely certain that a resting stage where the chromosomes are not visible does not intervene between this union of the chromosomes" and the young spermatocytes "where usually all the cells of a group contain nine distinct deeply staining loops with a somewhat crenate or beaded outline."

Evidence of a more general nature is that afforded, as Montgomery again points out, in his latest review of the subject, '04, by *Ascaris megalocephala univalens*, where only one chromosome of large size occurs in the young spermatocyte in place of the two present in the last spermatogonial division. Also, in those cases where two chromatin nucleoli (accessory chromosomes, McClung) appear in the spermatogonia and oögonia (*Anasa*) only one of these bodies appears after the synapsis, and this is then of a double character. At no point during this period is there even a suggestion of the throwing out of chromatin from the nucleus. It then seems evident in these cases, that the reduction is accomplished by the conjugation of the single individuals.

Still later is the preliminary report of A. & K. E. Schreiner, '04, on the Spermatogenesis in the Vertebrates, *Myxine glutinosa* and *Spinax niger*, where immediately following the last spermatogonial division the chromosomes, in the form of extended thin threads group at one pole of the reformed nucleus and

unite into pairs along their whole length, reducing the number to one half. This is in all regards similar to the description of the same stage given by Van Winiwarter, '02, in his excellent work on the oögenesis of the rabbit and man and that of Schoenfeld, '01, in the spermatogenesis of the ox.

The strongest corroboration of this main thesis, however, has lately come from the botanists. Very striking is the work of Rosenberg, '03 and '04, on the chromosomes of the somatic and germ cells of a hybrid between *Drosera longifolia* and *Drosera rotundifolia*. The former of these two species contains 40 chromosomes in its tissue cells and 20 in its germ cells, while the latter contains but 20 and 10 in its soma and germ cells respectively. In the hybrid, however, while the tissue cells contain 30 chromosomes, the germ cells in both sexes contain not 15, as one would expect, but 20. These 20 chromosomes, already present in their definitive form in the earliest prophases of the first maturation mitosis, are of two types: first, 10 large double structures showing a constriction in the middle; and second, 10 single ones. These are distributed irregularly over the spindle, only the double structures being properly placed in the equator. In the ensuing division, the latter 10 divide and pass to the poles to form the daughter nuclei, sometimes taking with them some of the irregularly placed ones which have not undergone any division. The majority of the single chromosomes, however, are left out in the cytoplasm where, after forming dwarf nuclei they degenerate. In the second division, the chromosomes split longitudinally and four daughter cells each containing, with but few exceptions, 10 chromosomes is the result. From the above, there is but little doubt of the conclusion drawn by Rosenberg: "Es wird also in den Pollen- und Embryo-sackmutterzellen etwa im Synapsisstadium ein von Drosera longifolia stammendes Chromosom mit einem Chromosom das von Drosera rotundifolia stammt vereinigt . . ., es können hier also nur 10 Chromosomen von Drosera longifolia von 10 Chromosomen von Drosera rotundifolia sozusagen gebunden werden. Die übrigen 10 Drosera longifolia Chromosomen finden keinen entsprechenden von Drosera rotundifolia und

müssen demnach als einfache Chromosomen neben den anderen 10 Doppel Chromosomen vorhanden sein, was auch thatsächlich gefunden worden ist. Ich finde also in dieser Erscheinung eine Bestätigung der Ansicht, dass einerseits bei der Reducktion eine Vereinigung von Chromosomen zu zwei und zwei stattfindet, anderseits, dass hierbei Chromosomen sich paarweise von jedem der Elternindividuen vereinigen.

In like manner, Cannon, '03, in his study of the spermatogenesis of the hybrid peas pointed out that as in *Peripatus*, etc., in the anaphases of the last sporogonous division of both hybrids and the pure form "Fillbasket," the chromosomes unite in pairs, thus reducing the number to one half. No such association into pairs is ever seen in the telophases of the normal somatic mitoses.

Still further, Farmer and Moore, '03, Lotsy, '04, Gregory, '04, Gregoire, '04, and Berghs, '04, and finally Strasburger, '04, himself, have in a large number of forms with but slight variations, found the same character of reducing process and ascribe to the synaptic phase the same significance pointed out above.

It is quite clear then, that in order to understand the reduction process we must turn to the early germ-cells (the oögonia and spermatogonial), and not to the oöcytes and spermatocytes ; for, in the latter, the number has already been reduced. There is, therefore, at the very beginning of the growth period, a condition of the chromatin which is known, making possible the study of the later processes. It is in this regard that the classic work of Häcker, Rückert and the other pioneers in the minute study of the chromatin of the germ-cells was weakest ; for correct as their interpretation of the bivalents is now seen to be, the origin of these structures was based on a very broad assumption which later research has entirely failed to confirm. In the presence of the characteristic synaptic phases synchronous with, or immediately following the last oögonial telophases, in these several *Copepods* and the other Arthropods generally, and from the subsequent appearance of the reduced number of bivalents in the early growth period, it is quite evident that the

phenomena in these groups where the processes are most fully known fall in line with the conceptions of Montgomery and Sutton.

C. Post-Synaptic Processes.

The reduction once accomplished, the chromosomes in the form of V-shaped bivalents show again marked plasticity. The arms of the V's split longitudinally, producing two sister structures united at several points along their course, and then become continuous through the increase of the angle to 180°. In this way are produced the parallel bivalent threads, like those in the *Copepods* or when the ends unite, the elongated rings described in *Gryllotalpa* (Vom Rath, '92). This extension of the angle is, in reality, no new process. Changes very similar were described by Vom Rath in *Gryllotalpa* and later by Paulmier in *Anasa* — cases from which that of *Pedicellina* differs only in that the changes are somewhat more pronounced. The figures of Häcker, moreover, point strongly to the probability that the parallel bivalent threads of the *Copepods* are also so formed. By the final concentration, these two types finally become in *Pedicellina* the rings and the elongated bars of the prophases of the first maturation division. But in either case, the structures are equivalent to tetrads, the longitudinal split (most clearly identified in the double bars) separating sister bivalents. We are thus presented with a complicated series of changes, in proper sequence, all leading to the formation of such a structure that its various parts may be distributed in the ensuing maturation divisions to different cells.

In the formation of the longitudinally split bivalent chromosomes, *Pedicellina* throws light on the whole problem of chromosome-development in the growing egg and sperm. Two types have been recognized to exist, as regards the origin of these bivalent chromosomes. In the first, a continuous spireme is said to arise in the earliest oöcytes, often already longitudinally split, which later segments into one half the normal number of double bars (*Copepod* type, Häcker). In the second, a continuous spireme is never formed. The reduced number of bivalent chromosomes appears at the very beginning in the form

of V's which later by the union of the free ends, form a ring. By further concentration, this figure may become a dumb-bell-shaped structure (*Peripatus*, *Brachystola*, etc.). In *Pedicellina*, as has already been pointed out, there is no continuous spireme and the early chromosomes are V's, in all regards like those of the second type, but by the opening up of the angle and the subsequent continuity of the univalent rods, are converted into the parallel bivalent bars of the first type. *Pedicellina* thus presents conditions that bridge over the two classes and shows clearly that these are really variations of one main type of chromatin formation.

In view of the foregoing facts, it may be questioned whether a continuous spireme really ever occurs even in the *Copepods*, as described by Häcker, '95. The work of Rückert, '94, does not show a continuous spireme at any point in oöcytic development. The parallel bivalents appear in the very early oöcytes and arise not through any process of segmentation, but rather by the moving apart, as growth proceeds, of the separate elements within the much crowded nuclei of the earliest period, *i. e.*, of the "synapsis" stage (cf. Figs. 1–2, Pl. XXI, '94, Anat. Hefte). Häcker's own figures are far from proving his contention, and are much more favorably adapted to an interpretation in line with what is observed in the other forms, *viz.*, *Peripatus*, *Brachystola* and particularly *Pedicellina*. Thus neither Figs. 5 nor 6, Pl. XIV, A. M. A., '95, representing the first type, *i. e.*, where segmentation occurs before concentration, nor Figs. 16–17, Pl. XV, of the second type, show continuous spiremes. They are more probably secondary appearances which have arisen by the apposition end to end of a considerable number of the parallel bivalents. This supposition is much strengthened by the conditions presented in his Figs. 7–11, Pl. XIV, where this apposition actually occurs to form not a continuous spireme, but rather, what Häcker designates as an ophiuroid figure. The author looks upon these as secondary unions, in contrast to the continuous spiremes which are primary structures ; but he gives no evidence for this distinction. The eggs are of the same age and the nuclei are in the same

point of development. Altogether the evidence points to the conclusion that the continuous spiremes and ophiuroid figures are alike in nature and represent, in somewhat different detail, the same process, viz., the secondary union of the ends of the already formed bivalents. In the first case the apposition is continuous, one bivalent being attached to the free end of the preceding; in the second, the ends of several bivalents are united at the same point. The difficulty has arisen, I believe, because Häcker has sought the process of reduction in the period of oöcytic growth when, as a matter of fact, it occurs at a very much earlier period in the early telophase of the last oögonial and spermatogonial divisions, where, through a process of convergence and fusion of univalent elements into pairs, the number is halved.

Once formed, the bivalents may persist individually as is so clearly shown in *Pedicellina*, both in the egg and in the sperm, or they may fuse into one deeply staining mass, emerging only later in their true form as in *Peripatus*. The *Copepods* are apparently of the same type. The characteristic "synapsis-stage" occurs, as Häcker himself asserts, and is clearly coincident with the last oögonial telophase. Following this synapsis stage, when the growth period sets in, the already formed bivalents apparently increase in size, lose in staining capacity, and cross and recross, giving rise to the confusing figure which Rückert describes (cf. his Fig. 3, Pl. XXI), and from which, with the growth of the nucleus, the parallel rods emerge. Before this clearing-up process, however, when the chromosomes are still much crowded, they may unite end to end in a long chain to form the continuous spireme of which Häcker speaks. The conditions in the spermatogenesis of the Amphibia present an interesting corollary to the above discussion. Flemming, '87, and a number of others have described a continuous spireme in the spermatocytes which segments, as in the *Copepods*, into the reduced number of bivalents. Montgomery has, however, in a very recent work, been unable to find the continuous spireme and describes a type of reduction quite similar to that he observed in *Peripatus*. To this conclusion we shall return presen

At the close of the growth period, the most striking elements in the oöcyte and spermatocyte nuclei of *Pedicellina* are the several ring- and their equivalent double rod-figures. The former of these recall the heterotypic mitoses observed in the Amphibia, the Platodes and the flowering plants. In the first of these groups, first Flemming, '87, and later Hermann, '91, Meves, '96, and others, interpreted the rings as having arisen, in the early spermatocytes, through the opening up of the space between the sister chromosomes which had separated in the early longitudinal splitting of the spireme. On this interpretation, the space within the ring is thus between like halves and from the relation of the ring to the spindle, the subsequent division is necessarily equational. According to Montgomery, on the other hand, who has lately investigated this subject, the above authors, as well as most others who have worked on Amphibian spermatogenesis, have overlooked some very essential stages in the origin of these rings. Thus he maintains that what these authors have taken for sister chromosomes in the early spermatocytes, are really not such but different univalent chromosomes which have, as in *Peripatus*, united end to end in the previous synapsis, and that the true longitudinal split is of different origin. As has been already observed, this author finds no continuous spireme and consequently no segmentation of the latter into the reduced number of bivalent longitudinally split threads as Flemming and the rest have done. According to him, the young spermatocytes show a reduced number of V-shaped chromosomes. These present the same characteristic polarity, the connecting band of linin at the apices and the wide extension of the angle described for *Peripatus*. The true longitudinal split occurs very early along each of the arms of the V or the U, soon, however, disappears, only to reappear much later in the dyads of the anaphase of the first maturation mitoses. The free ends of the longitudinally split arms of the V's now unite to form the rings of the metaphase. The first division would, on this hypothesis, obviously be a reducing one.

Whatever be the true interpretation of these rings in the Amphibia, they are in the maturation divisions of *Pedicellina* of

a very different nature, since they arise by the opening up of the angle of the primary V's to form the straight, bivalent, longitudinally split, parallel rods which, by later uniting at both pairs of ends form a ring, as in *Thalassema* or the *Copepod*. Each quadrant is, therefore, in *Pedicellina*, a chromatid (McClung), and not one half of one as appears in the Amphibia from both Flemming's and Montgomery's interpretation. It may therefore be said, that from the time of the straightening out of the rods in the early oöcytes, up to the first maturation, *Pedicellina* parallels closely every essential process to be observed in the chromosome formation in the *Copepods*.

As has been previously observed, the rings are not limited in their presence to the maturation divisions. At variance with the assertion of Montgomery, '04, that the heterotypic mitoses is always a reducing division, the rings in *Pedicellina* occur in addition not only in the divisions of the primordial germ cells, as Häcker found in the *Copepods*, but they occur in the somatic tissues as well. It is clear that in these cells the rings are of an entirely different constitution from those found in the maturation divisions. In the former, they are only transient structures which have arisen by the temporary connection of the ends of the daughter V's, at the metaphase, while in the latter they represent structures which have had a long history in their formation and are essentially adaptations for the proper equipment of the germ cells. It is therefore not the form but the constitution of the rings that is of importance for the proper interpretation of the nature of a division.

(*D*) *The Maturation Divisions.*

The problem of the maturation divisions is not at the present time, in a very satisfactory state. On the one hand, in a considerable number of forms of which *Crepidula* (Conklin, '02) and *Echinus* (Bryce) are typical, the chromosomes are not visible as such during the growth period of the egg, and appear in very nearly their final form only shortly before the first maturation division. In such cases it is obvious that the nature of the division is full of uncertainty, and such indeed, has been the

attitude of the majority of the workers on these forms. On the other hand, in those cases, where the early history of the chromosomes is more fully known, and where from the final constitution of these structures a reduction division almost certainly occurs, there opinion is much divided as to whether the first or the second division is the reducing one. The chromosomes, mainly in the form of tetrads, rings and crosses, are often so symmetrical that the two axes, *i. e.*, the longitudinal and the transverse, cannot be distinguished. In *Pedicellina*, while these types of chromosomes occur, they are not the prevailing types. Fortunately, the peculiarly favorable bars which persist from the earlier growth period and whose history is very completely known, occur in the large marjority of instances and are so located in the spindle throughout the phases of division, as to leave no doubt that the first maturation division is, in both egg and sperm, the reducing one. In this regard, the condition in *Pedicellina* are in accordance with the results of a constantly increasing number of workers, botanists as well as zoölogists, whose results are based on a particularly full history of the earlier stages of the chromosome formation.

At this point the Platodes present very instructive conditions for comparison. At the end of the growth period both the rings and ellipses so characteristic of *Pedicellina*, and the bar-shaped figures are present. While on this point all the workers are, on the whole, agreed, a difficulty in the interpretation has of late been introduced in the last work of Schockaert, '02, on the ovogenesis of *Thysanozoön*. This author, in a most painstaking work, confirming the presence of the figures of the various forms noted above, and agreed further with this work on *Pedicellina* in considering the first maturation division the reducing one, comes to this similar conclusion on grounds which are entirely at variance with the process described, not only in this work, but in nearly all of the other studies on the Platodes. This is all the more striking in the light of what I take to be a complete correspondence in the earlier changes in the germinal vesicle in the two forms. After a synapsis stage coincident with the telophase of the last oögonial division, the

chromosomes in the reduced number appear in *Thysanozoön* as nine distinct loops, showing the same polarity and other characteristic features described for *Peripatus*, *Brachystola*, *Sagitta* and *Pedicellina.* The bivalents, further, split longitudinally, but at this point, according to Schockaert, the resemblance stops. These chromosomes do not give rise to the structures of the maturation division, but begin to disintegrate and a chromatin reticulum is formed. After a considerable period of growth, the chromosomes again reform and present themselves as elongated rods, which are more or less clearly longitudinally split. The author is not sure of their number, but from the text and figures, it may safely be inferred that they are present not in the normal, but the reduced number. — "En effet, lorsqu'on compte, dans toutes les coupes successives d'un même ovocyte, les différents tronçons persistants du filament nucléinien, on en trouve tantôt plus de neuf, tantôt moins ; même en prenant en consideration la multiplication accidentelle de ces tronçons par la section du rasoir on constate que leur nombre est tres inconstant." It is at this point that the difficulty arises. The chromosomes now concentrate, removing all signs of the longitudinal split, and conjugate two by two along their length. The split between the homogeneous conjugants is therefore not a longitudinal split as nearly all the previous observers (Klinckowström, '97, Francotte, '97, and Van der Stricht, '97) have maintained, but represents, rather, a space between "portions transversales . . . en train de s'accoler." After some slight modifications, these figures present themselves to the spindles in three somewhat different forms : "des anneaux ou des ellipses, des bâtonnets recombés en crochet a leur extrémités et des bâtonnets longs et droits. Ces trois formes sont dues à l'insertion différente des fibres fusoriales sur les deux branches qui constituent les chromosomes lors de leur génèse." These lie with their long axes in the long axis of the spindle and the first division is therefore the reducing division. In the early anaphase, the dyads in the form of U's and rods show again their longitudinal split, which had disappeared early during the concentration period and from this point onward the processes

are distinctly like those described by all authors for the Amphibia. The second division is then longitudinal.

After a careful examination of the evidence adduced in its favor, I am convinced, in the light of the processes described in *Pedicellina*, that the fundamental conception of Schockaert's is full of difficulty. It is quite evident that the crux of the whole question lies in the origin of the figures of the maturation division. But as the author himself points out, there is no structural continuity between the bivalvents of the early oöcytes and the longitudinally split rods which later conjugate. It is this hiatus that throws uncertainty on the constitution of these latter structures, and which makes positive interpretation of the later stages quite impossible. What is more damaging, however, is the fact that these structures are present in what appears to be the reduced number. Should this be the case, the supposed succeeding conjugation would still further reduce the chromosomes to one quarter the normal number, and the probability of the process, for which very little evidence is given, would be destroyed.

Altogether, it seems far more probable, on the evidence presented, to consider the extended double rods of the late growth period (Fig. 50, Pl. IV) not as the result of a post-synaptic conjugation, as the author has done, but rather as persistent structures from the earliest oöcytes. The single rods would then each correspond to one half of the loops of the synapsis period. As in *Peripatus* and *Brachystola*, the pair of free ends of the loops, I believe, come later into connection and thus produce the rings and ellipses, and by the still further lateral union the homogeneous "bâtonnets" of the maturation figure. As in these Arthropod types, also, the early longitudinal split in the loops has disappeared to reappear later in the anaphase of the first maturation division. The resulting structures are, to be sure, of such a constitution as to insure the same result in the first division as Schockaert concludes, but they are thus derived through a series of processes in accordance with what has been most clearly observed in other forms, but what is more significant, in a manner in far better agreement with the figures.

From among the botanists, however, has come very recently convincing evidence in favor of the reducing division as a constant factor in the formation of the germ cells. Gregoire and Berghs, Farmer and Moore, Gregory, Lotsy, and, most important of all, Strasburger, have, in a series of important works, all concluded in favor of this division — many of the above having, in the past, been the foremost advocates of the antagonistic view, viz., that the two maturation divisions are both longitudinal or equational. Typical of the rest is the work of Strasburger, After a careful reëxamination of his old material, *Tradescantia*. etc., he has abandoned his old views and in a new form *Galtonia* in which the conditions for study are exceptionally favorable, describes processes from which the presence of a reducing division is unavoidable. The twelve chromosomes of the early germ-cells unite into six double structures in the synapsis stage, and these bending upon themselves and uniting at their free ends become the rings of the first maturation. It is in this division that the univalent components are separated, the division being thus transverse or reducing. The second maturation mitosis then ensues and the chromosomes, as in the ordinary somatic tissues, split longitudinally and pass to their respective cells. There is thus, on the authority of a constantly increasing number of investigators, a condition of the germ-cells which, as Sutton and Boveri have pointed out, alone can explain and give basis for the very common and now almost universally recognized Mendelian phenomena of heredity.

E. Comparison of Oögenesis and Spermatogenesis.

Finally, it is of considerable interest to find in *Pedicellina* the complete similarity between the long series of processes in the development of the germ-cells of both sexes. In the several generations and nature of the oögonia and spermatogonia ; in the presence of the V's ; in the last oögonial and spermatogonial telophase, with the subsequent reduction of the chromosomal number ; in the further history of the bivalent V's thus formed ; their lengthening, irregular distribution within the nucleus and the longitudinal splitting of their arms, the early male

and female germ-cells are quite alike. Further, the several complicated changes which finally lead to the formation of the figures of the maturation divisions, as well as these divisions themselves, are in both instances quite identical. Under such conditions as these it is clear that, whatever be the different rôles which the egg and the sperm play in development, they are, at bottom, morphologically equivalent and diverge only secondarily in adaptation to their respective functions. We may at the present day appropriately conclude with the words of the classic study of Oskar Hertwig: "Vergleich der Ei-und Samenbildung bei Nematoden": Eibildung und Samenbildung sind zwei einander nahe stehende Processe; sie gehören soeng zusammen, dass die Kenntniss des einen nothwendiger Weise auch das Verständniss des anderen fördern muss, sofern man nur durch Vergleichung die gegenseitigen Beziehungen festzustellen sucht."

Summary.

1. In *Pedicellina americana*, the polypides are of separate sexes, but both male and female individuals may occur on the same stolon.

2. The ovaries and testes are bilaterally symmetrical organs. Unlike the testes, where the germ cells are irregularly distributed, in the ovary, a continuous line of development of the egg cells can be traced from the center outward.

3. The processes of oögenesis and spermatogenesis are, in general, quite identical.

4. In young male and female polypides, the primary egg and sperm cells lie nearest the oviduct and spermduct respectively, and give rise through mitosis to the several generations of oögonia and spermatogonia.

5. With the exception of the last generation of spermatogonia, the chromosomes are V-shaped, as are those of the tissue cells. The normal number of chromosomes is very probably twenty-two.

6. In the last generation, they appear as dumb-bell shaped rods and have arisen by the opening-up of the angle of the former V's.

7. These divide, appear as rods in the anaphase, and in the telophase give rise to both egg and sperm to eleven or the reduced number of larger V's. This is the synapsis stage.

8. In the youngest oöcytes and spermatocytes, the chromosomes are localized at one pole, having retained both form and place in which they appeared in the preceding oögonial and spermatogonial telophase.

9. The loop-shaped chromosomes grow very rapidly and soon extend throughout the cells.

10. The arms of the loops become granular and are longitudinally split.

11. The split bivalents increase the angle between the arms to 180° and then appear as elongated parallel threads of the *Copepod* type.

12. There is no continuous spireme.

13. The parallel bivalent threads may unite at both pairs of ends to form elongated rings, twine around each other to form 8-shaped figures, or come into more intimate relations along the whole length, thus forming extended longitudinally split bars.

14. These concentrate into the rings and double bars of the first maturation division.

15. At the metaphase almost all the chromosomes are of the elongated longitudinally split rod type, the longitudinal split lying in the long axis of the spindle.

16. The first maturation division passes through the points of synapsis, and is the reducing division.

17. The longitudinal split does not generally appear in the early dyads, but again makes its appearance in the prophases of the second division as a new construction in the middle.

18. The second division is a longitudinal one.

19. The eggs are fertilized internally, pass through the oviduct into the atrial brood pouch where they develop.

20. The pronuclei do not unite intimately. The chromosomes are very early reformed and give rise to twenty-two V's of the first somatic mitosis.

21. They split longitudinally and preserve this form throughout all the later divisions up to the last spermatogonial, and very

probably oögonial generation, where they are converted into dumb-bell shaped rods.

22. The egg nucleolus appears early during the oöcytic growth period and increases in size at the expense of the cleavage products of the chromatin.

23. It later becomes much vacuolated, stains throughout as a plastin body, and with the approach of the first maturation division disintegrates, its remains being cast out as a metanucleolus (Häcker).

Columbia University, Dept. of Zoölogy,
October, 1904.

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PLATES I–III.

All the figures here presented were drawn with the aid of the camera lucida and then redrawn, magnified nearly two times, with the aid of another camera apparatus. Various magnifying powers were employed at different times and will be specified in connection with the figures. The plates were then all reduced in the reproduction, to their original size.

PLATE I.

Plate I.

(*Spermatogenesis.*)

Fig. 1. Longitudinal section of an early testis, showing various generations of spermatogonia in rest and in division. Magnification: Obj. D (Zeiss) × 4.oc.

Figs. 2–61. Were all drawn under the same magnification: Zeiss, homog. immersion 1.5 mm. Ap. 1.30 × 12 compens. ocular, tube-length, 160 mm.

Fig. 2. Cross section of metaphase, early generation of spermatogonia showing V-shaped chromosomes.

Figs. 3–6. Longitudinal section of late prophase and metaphase of same showing attachment to the spindle.

Fig. 7. Middle anaphase of early spermatogonium.

Fig. 8. Telophase of same showing dense crowding of chromosomes.

Figs. 9–11. Longitudinal sections of prophase and metaphase of last spermatogonial generation showing rod-shaped chromosomes.

Fig. 12. Cross-section of metaphase of the same.

Figs. 13–14. Early anaphase of last spermatogonial division.

Fig. 15. Late anaphase of same.

Fig. 16. Early telophase showing the union of the individual rod chromosomes into pairs.

Figs. 17–18. Late telophase where the synapsis has already occurred.

Fig. 19. Earliest spermatocyte showing the newly formed bivalents moving apart.

Fig. 20. Somewhat later stage chromosomes showing marked size differences.

Figs. 21–22. First traces of longitudinal split.

Figs. 23–24. Opening up of the angle of the longitudinally split bivalents.

Fig. 25. Sister bivalents united at their both ends to form the elongated rings.

Fig. 26. Somewhat later stage than preceding. Chromosomes beginning to concentrate and showing the other type of double rod in which longitudinal split is obscured.

Figs. 27–30. Further stages in concentration in preparation for 1° maturation division showing rings and double bars side by side.

FIG. 31. Earliest prophase of 1° maturation division.

FIGS. 32–34. Prophases of 1° maturation division showing the two main types of chromosomes, the rings and the much elongated, longitudinally split, rods.

FIGS. 35–37. Longitudinal section of 1° maturation spindles in metaphase showing the predominance of rods.

FIG. 38. Cross-section of the same.

FIGS. 39–40. Longitudinal and cross-section respectively of late metaphase.

FIGS. 41–42. Early anaphase of 1° maturation division showing separation of the dyads.

FIGS. 43–44. Later anaphases showing in some instances the true nature of the dyads.

FIGS. 45–46. Early and late telophase of 1° maturation division.

FIGS. 47–48. Longitudinal and cross-section of metaphase of 2° maturation division.

FIG. 49. Early anaphase of same showing strand of chromosomal substance connecting the monads.

FIGS. 50–52. Middle and late anaphase of 2° maturation spindles.

FIGS. 53–54. Early and late telophase of the same.

FIG. 55. Young spermatid after breaking down of the dense chromatin mass of the preceding telophase.

FIG. 56. Early differentiation of the sperm head and concentration of the chromatin before and behind.

FIGS. 57–60. Elongation of head; filling up of open spaces with chromatin substance and formation of middle piece and tail.

FIG. 61. Mature spermatozoön.

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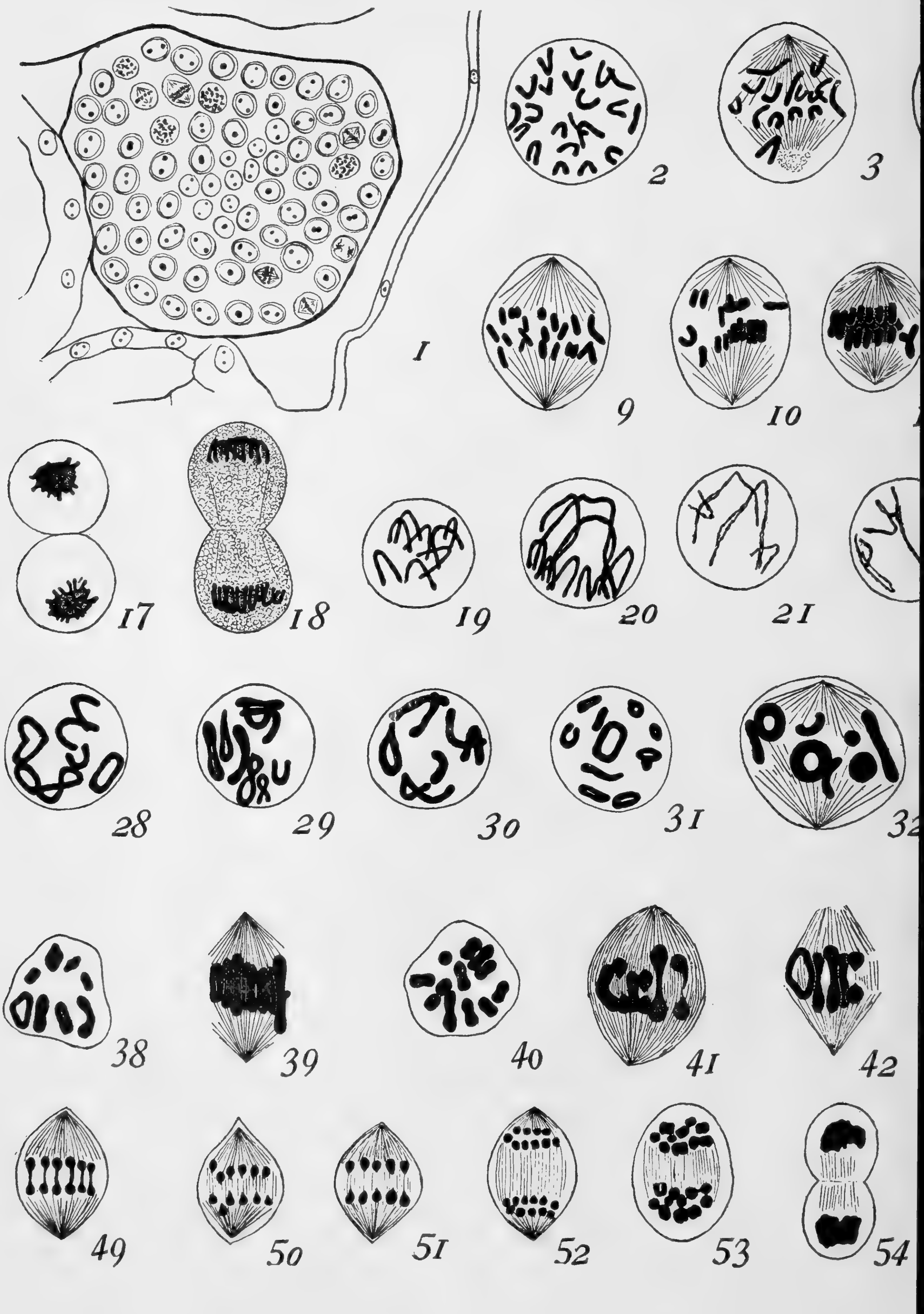
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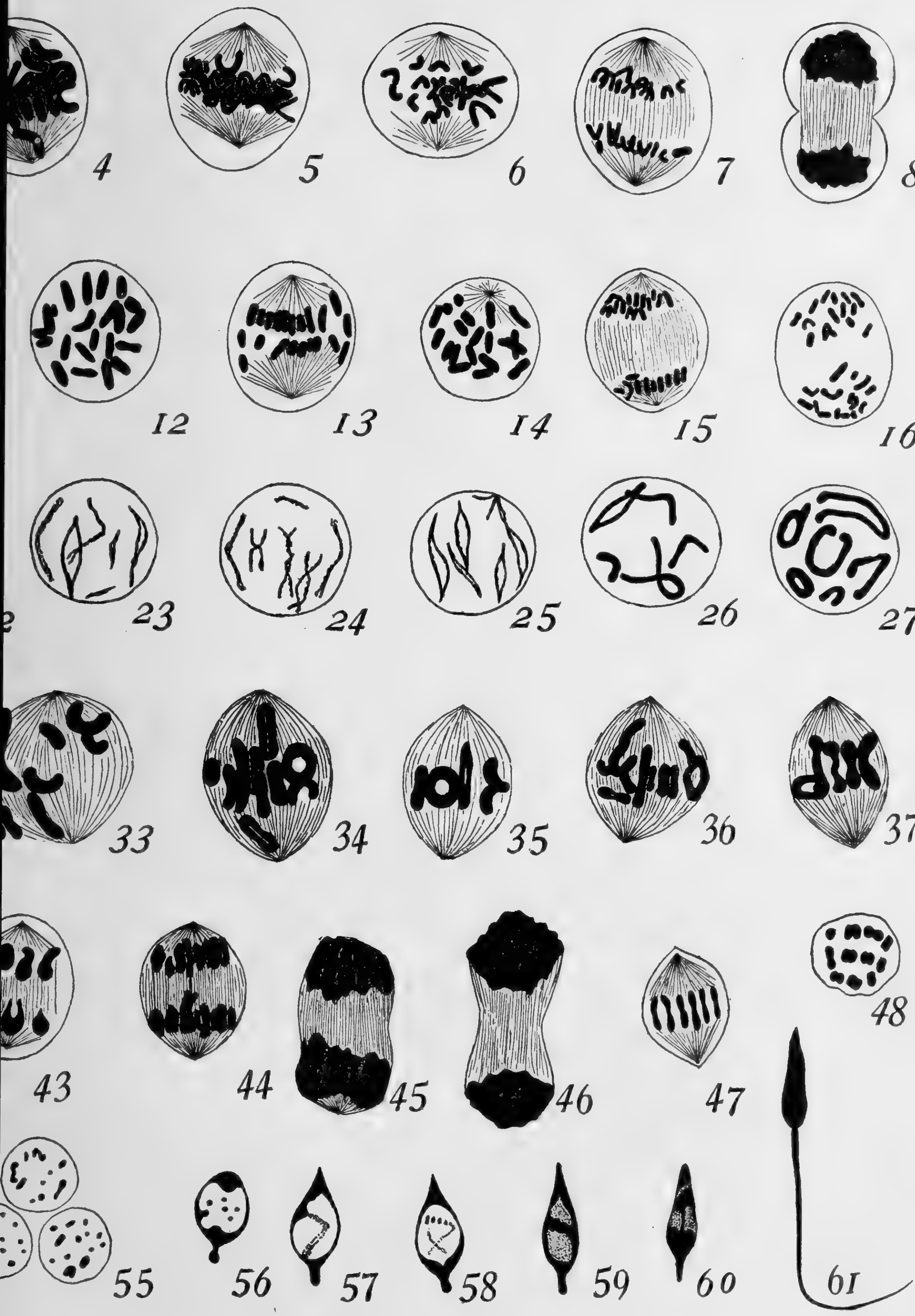
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PLATE I.

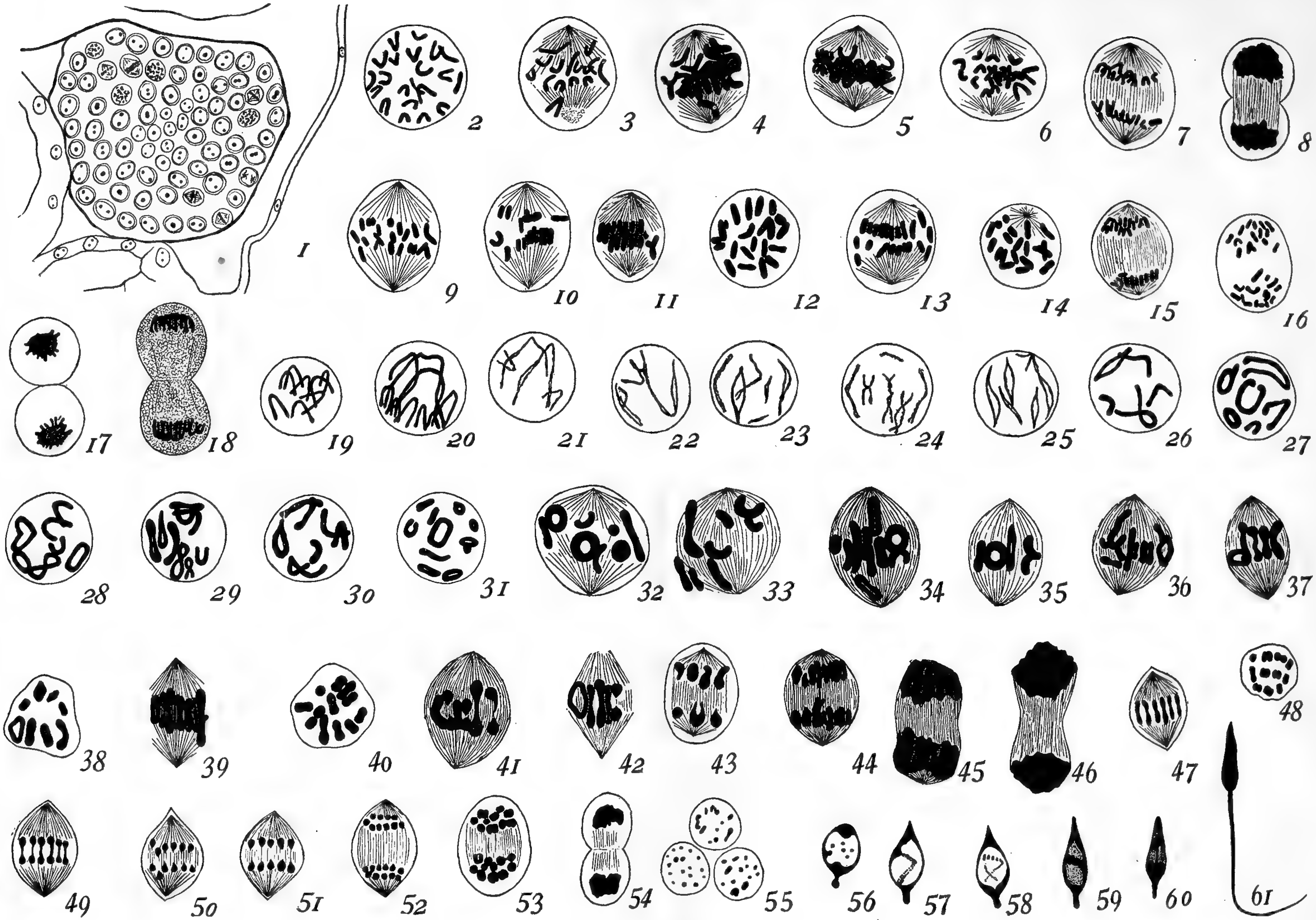
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PLATE II.

Plate II.

(*Oögenesis.*)

Figs. 62–66 were magnified with Zeiss, homog. apoch. immers. $\frac{1}{18}$ × 12 compens. oc.; the remaining figures, with exception of 101–105, being drawn under Zeiss $\frac{1}{18}$ obj. × 4 oc.

Fig. 62. Cross section of metaphase of early generation of oögonium showing V-shaped chromosomes.

Fig. 63. Early generation of oögonium in metaphase in longitudinal section.

Fig. 64. Telophase of the same.

Fig. 65. Last generation of oögonium in metaphase showing chromosomes as rods.

Fig. 66. Last generation telophase showing synapsis; also synaptic knobs at apices of V's in lower cell.

Figs. 67–70. Early oöcytes, showing polarity of chromosomes and synaptic knobs at apices.

Figs. 71–72. Early oöcytes with chromosomes increased in size.

Figs. 73–74. First traces of longitudinal split in young oöcytes.

Fig. 75. Oöcyte with nearly all the chromosomes longitudinally split.

Figs. 76–78. Oöcytes with chromosomes opening out into longitudinally split parallel threads.

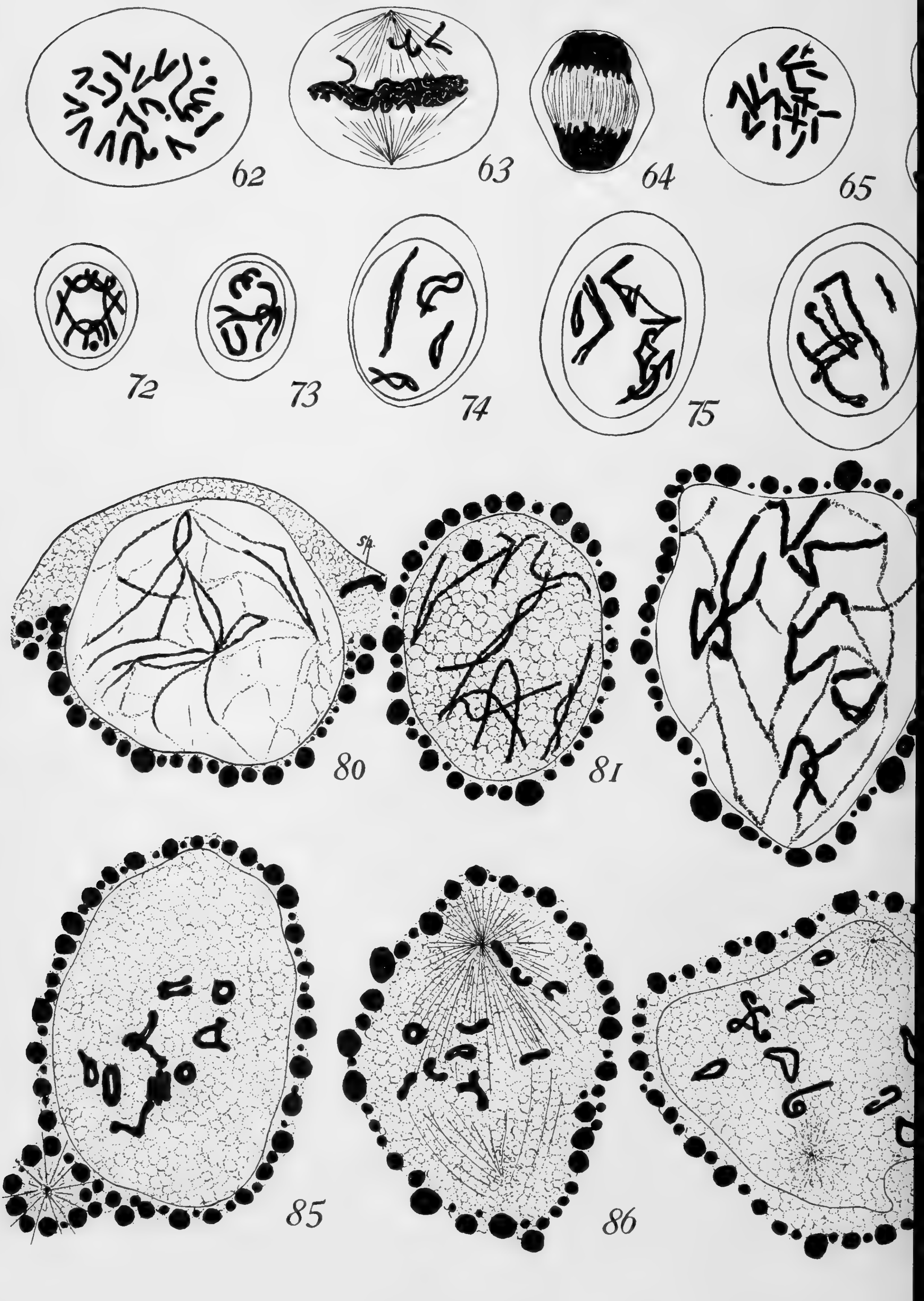
Figs. 79–81. Later oöcytes showing the parallel threads separating along their course but often remaining united at one of their ends.

Figs. 82–83. Two successive sections of the same nucleus. Showing the chromosomes at the height of the growth period.

Fig. 84. Oöcyte with chromosomes concentrating into the rings and double rods of the first maturation division.

Figs. 85–87. Early prophases of 1° maturation division showing chromosomes much more concentrated.

Figs. 88–90. Late prophase and early metaphase of 1° maturation division showing the rings, longitudinally split rods, crosses and true tetrads.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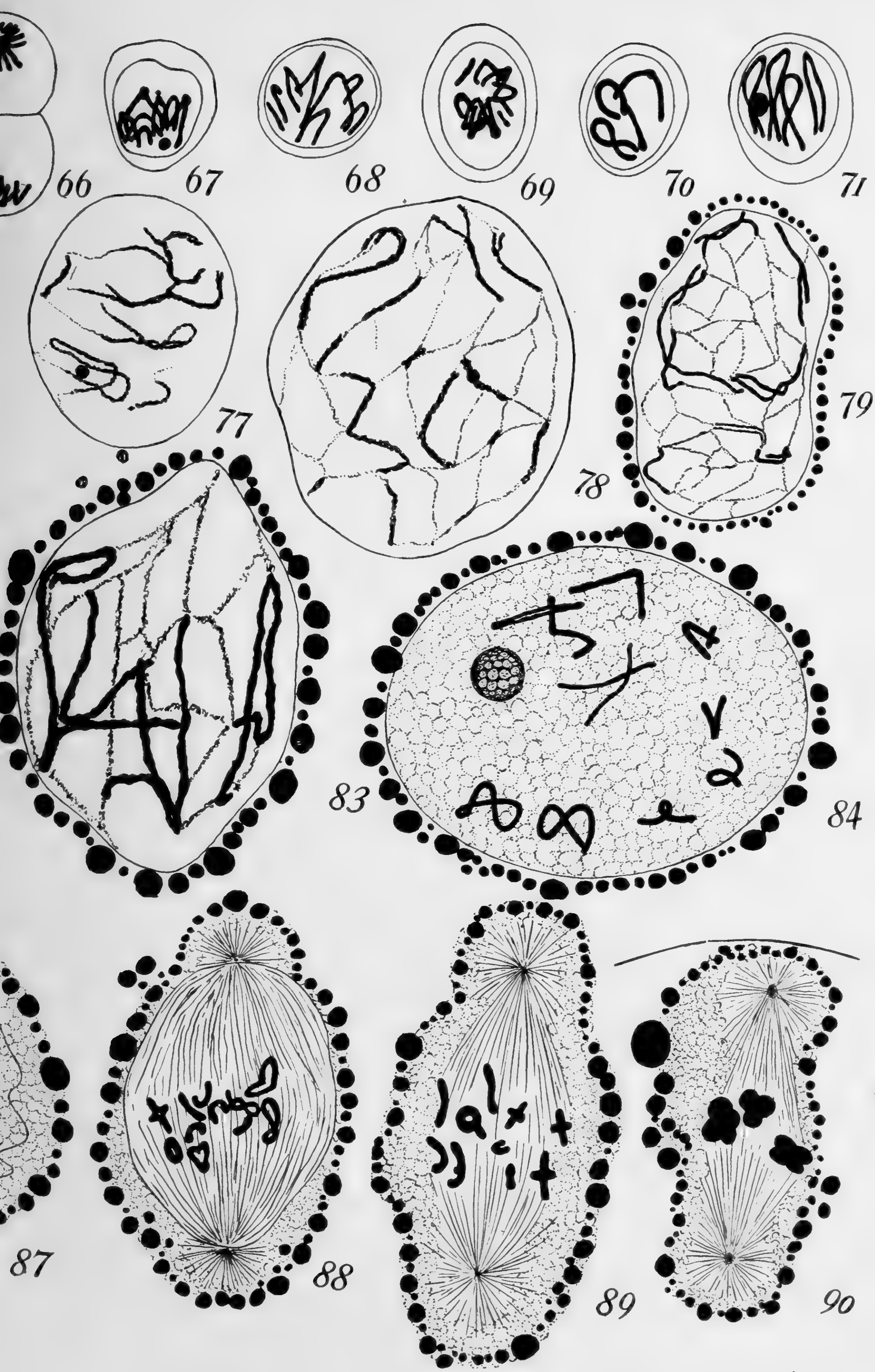
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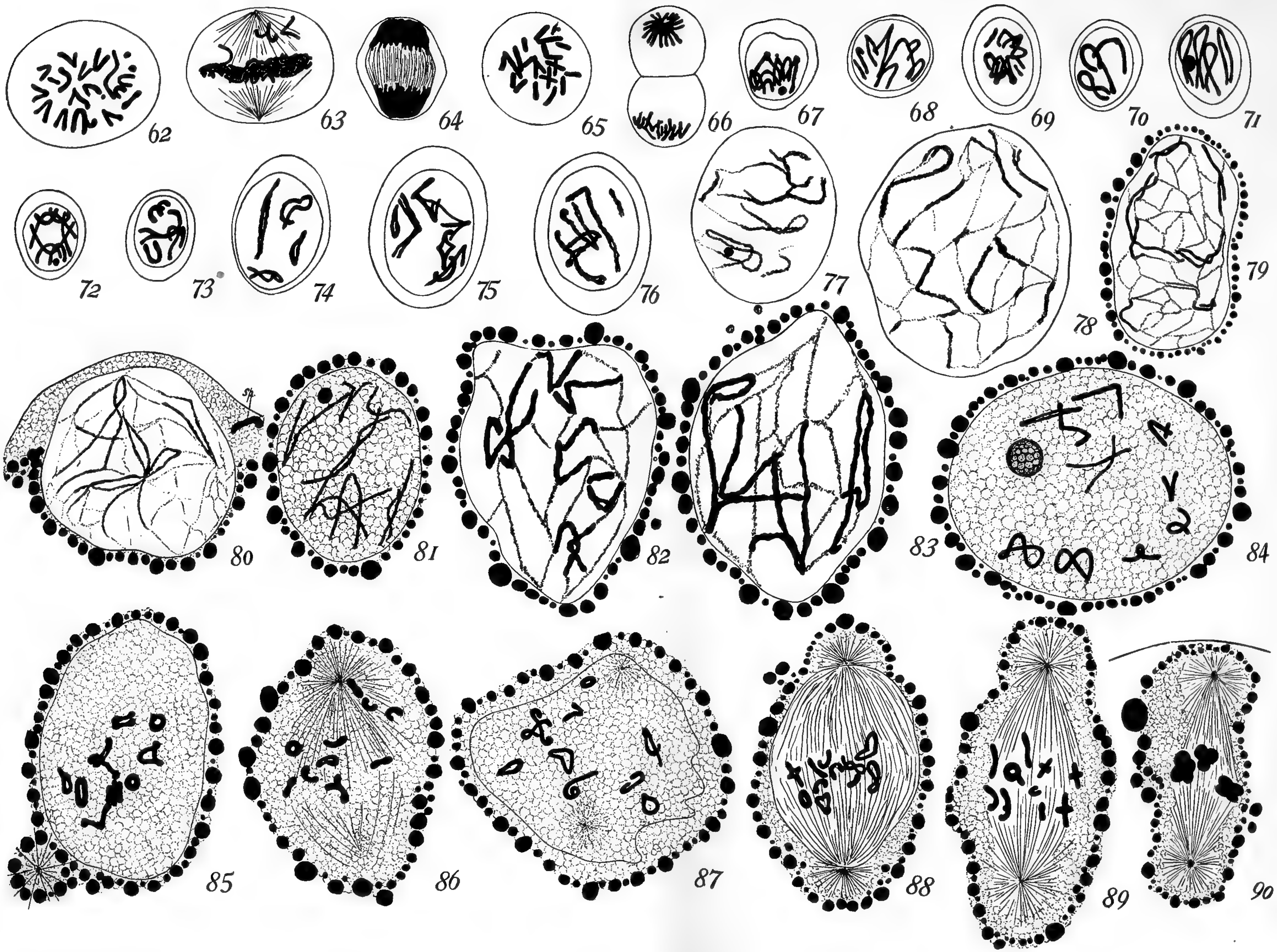
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PLATE III.

PLATE III.

(*Oögenesis continued.*)

FIGS. 91–93. Metaphase of 1° maturation; the chromosomes nearly all converted into elongated rods.

FIGS. 94–95 (*a* and *b*). Early anaphase of the same showing the elongation of the chromosomes and the chromosomal strand connecting the dyads.

FIG. 96. Prophase of second maturation showing the newly formed spindle inclined 90° to the foregoing; also, the first polar body.

FIG. 97. Somewhat later prophase with spindle revolved into proper radial axis.

FIG. 98. Metaphase of 2° maturation division showing longitudinal division of dyads.

FIGS. 99–100. Anaphase and telophase, respectively, of the same.

FIG. 101. Later telophase of 2° maturation division; formation of second polar body.

FIG. 102. Division of 1° polar body in metaphase showing some character of chromosomes as in second maturation within egg.

FIG. 103. Cross section of metaphase in division of a "liver-cell"; V-shaped chromosomes as in the early generations of oögonia and spermatogonia.

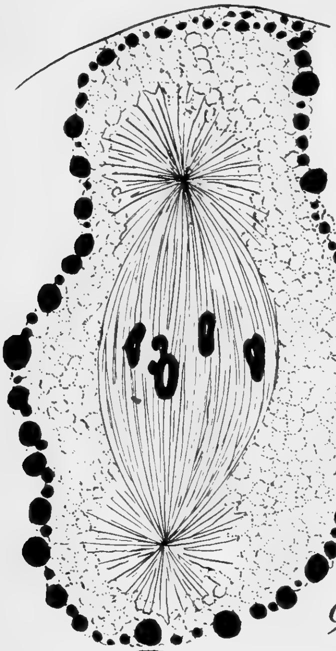
FIG. 104. Telophase of atrium cell showing the presence of the unreduced number of the V-shaped chromosomes in contrast with the reduced number of such structures in the telophases of the last generation of spermatogonia and oögonia Figs. 18 and 66.

FIG. 105. Prophase of division in atrium cell showing both the V and ring chromosomes.

FIG. 106. Fusion of the male and female pro-nuclei, the latter being nearer the egg periphery. The chromosomes are concentrating from the earlier reticulum to the definite V-shaped chromosomes of the 1° somatic division.

FIG. 107. 1° somatic mitosis, prophase showing twenty-two V-chromosomes.

FIG. 108–109. Metaphase and anaphase of the same.



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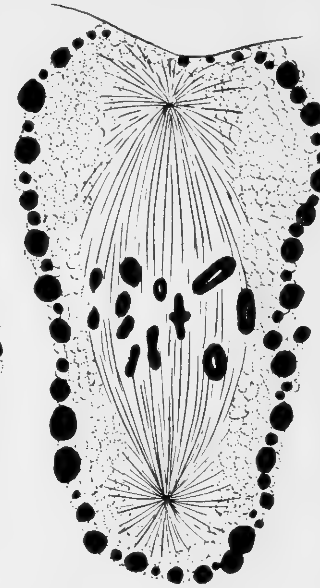

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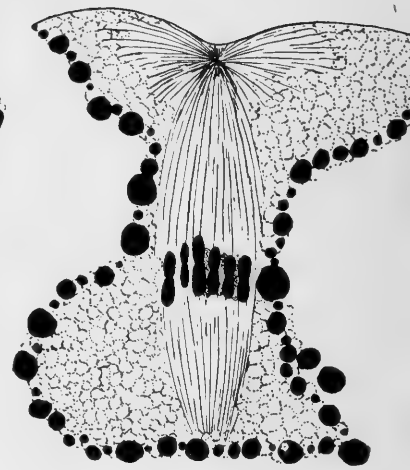

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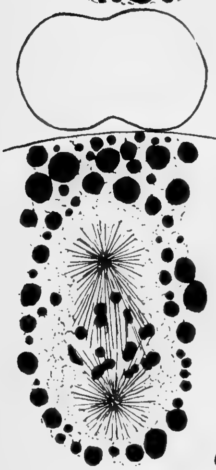

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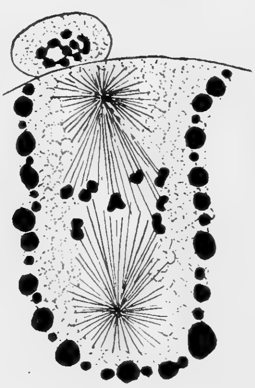

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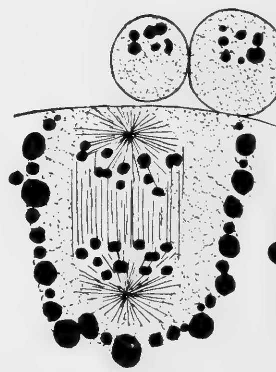

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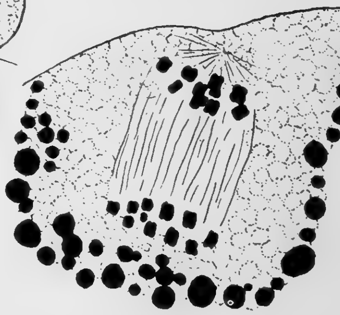

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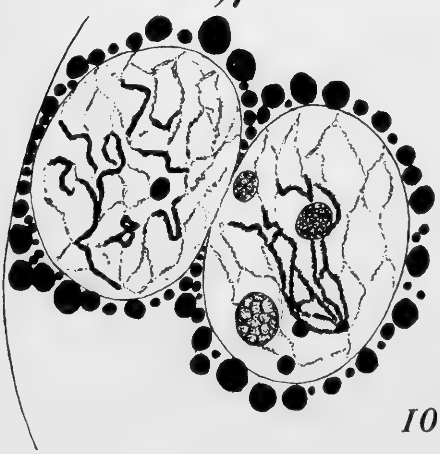

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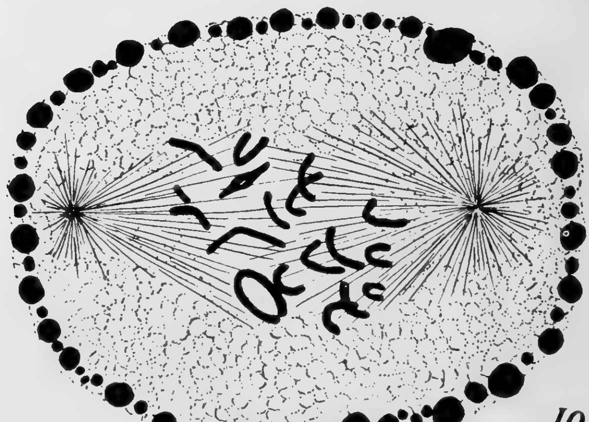

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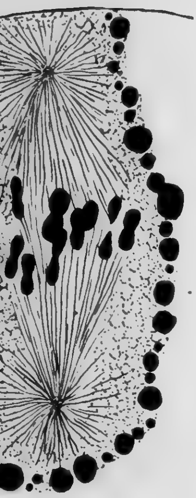
PLATE III.



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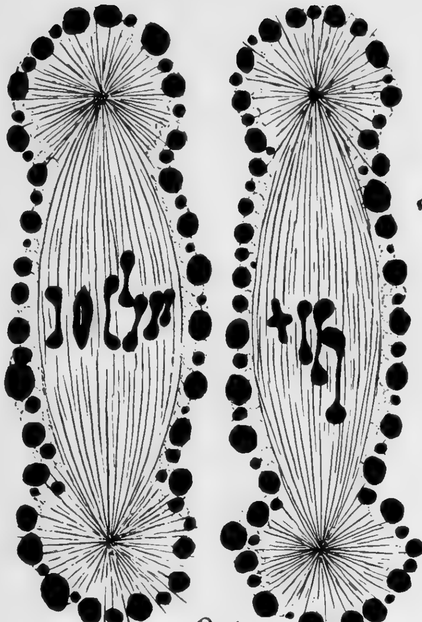

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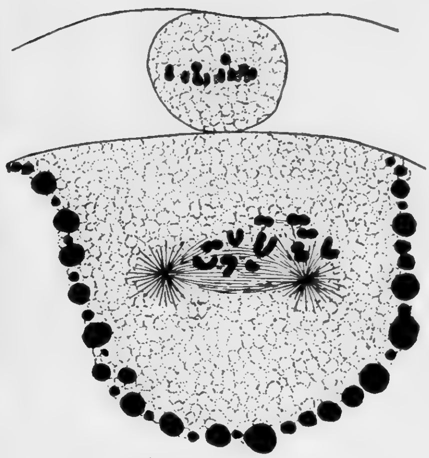

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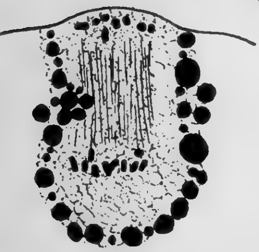

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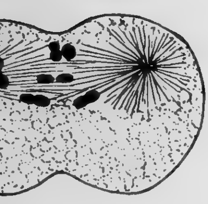

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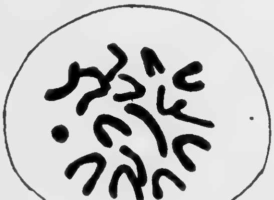

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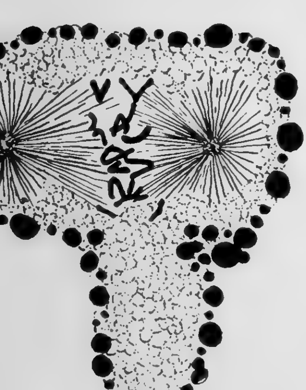

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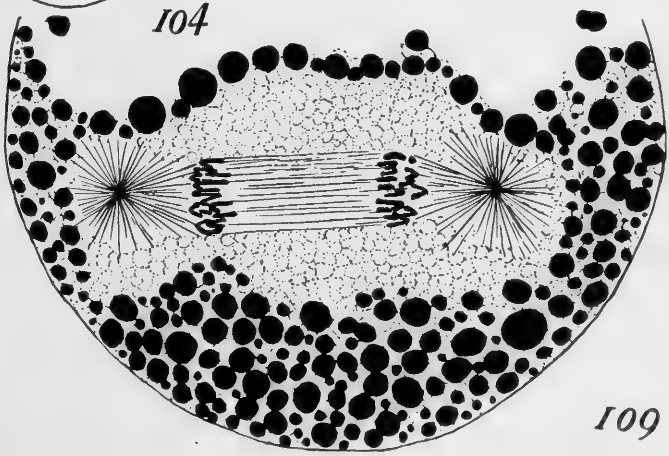

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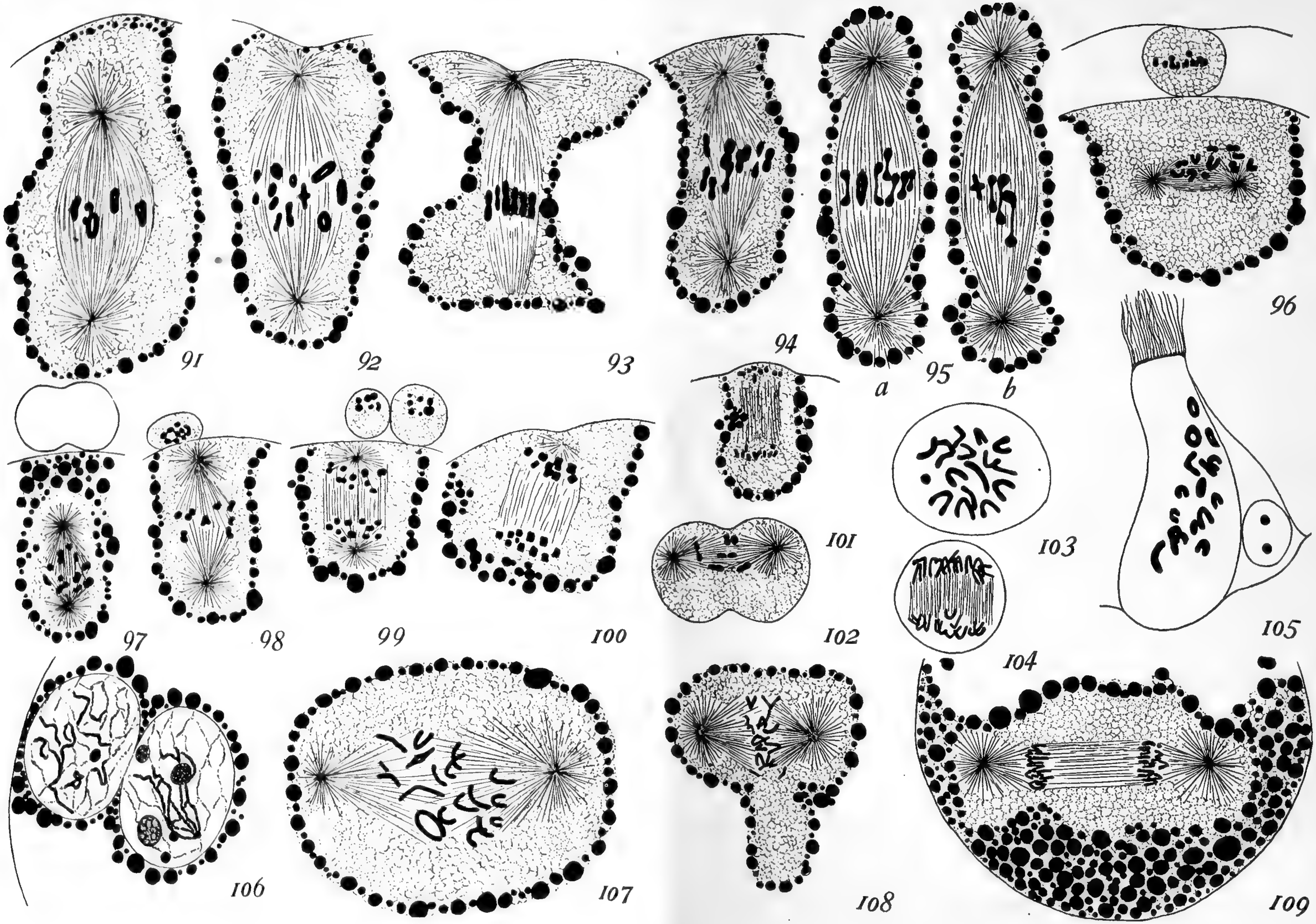
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[ANNALS N. Y. ACAD. SCI., VOL. XVI, No. 2, pp. 65–74, March 17, 1905]

RECENT JOURNEYS AMONG LOCALITIES NOTED FOR THE DISCOVERY OF REMAINS OF PREHISTORIC MAN.

J. HOWARD WILSON.

(Read January 18, 1904.)

There are some subjects which by their very nature enter so little into the lives of most men that they are almost unknown, and are rarely thought of or studied; another again, although of great interest to a small group of students and specialists, may not occupy the thoughts of the generality of mankind for the simple reason that the subject is so new, or as a science is still so in its infancy as not to attract public attention.

Although anything which sheds light on the history and origin of man should not fail to awaken the greatest interest, it is probably on account of these two reasons, that prehistoric archæology is as yet so little known.

But prehistoric archæology has taken its place among the other sciences. Little by little, the longing for knowledge of the human race, far back beyond the beginnings of history and the occasional finding of implements in stone or bronze, made and used by the people of those remote ages, have quickened the interest in the subject, until it has developed into the science it is to-day with its enthusiastic savants and great collections both public and private.

For a long time, when stone implements were found or ploughed up in the fields, their true nature was not generally known. Often however they were recognized as differing from ordinary stones and came to be accredited with peculiar properties, and made the subject of superstitious regard. In Europe generally, and in other parts of the world, the flint axes were called "thunder stones" by the peasants, who thought that

they descended from Heaven and that the presence of one in a dwelling would be certain protection against lightning. There is mention of a stone ax found in Egypt engraved with hieroglyphics which showed that its unusual character was noted and that it had been kept perhaps as a kind of talisman. Later on the stone axes and other implements became recognized, especially by antiquarians as the works of a people who with their civilization had long since passed away. At the same time, the science of geology was developing and making headway. The different kinds of rocks and their formation became better known, and the real nature of the sedimentary with their fossil contents, which had given rise to many wild and curious theories became thoroughly recognized and established. Cuvier, called the Father of Anatomy, gave the first powerful stimulus to the study of the fossil vertebrates, mostly species now extinct, and finally the question began to be asked, "Is there a fossil man?" Although used in its broadest extension, the term fossil is taken to signify any evidence of former life, it is generally meant that the remains antedate the present epoch and belong as far back at least as the Quarternary or last geological period. The Quarternary opened with the development of the great continental ice sheets in Northern Europe and North America, to which the name Ice Age owes its origin, and closed with the ushering in of the climate and physical conditions approximating those we have to-day. It is in deposits formed during the Glacial Period that the earliest authentic traces of man have thus far been found. In glacial gravels, the diluvium of rivers, in caves, and deposits formed during the Glacial Period and later, the implements and works of man have been found. Human bones are preserved for so long a time only under exceptional circumstances and are very rare. In the river gravels of the Somme in France where the implements are comparatively abundant, great numbers having been found, no human bone has as yet come to light, but, as has been remarked by Sir John Lubbock, the bones of no animal as small as man are preserved in the river drift deposits.

One of the first finds recorded was that of a worked flint,

discovered with an elephant tooth in the quaternary deposits of London, in 1713, but its significance was not appreciated at the time. The finding of other flints at Hoxnie in Suffolk in company with the fossil bones of some large animal and at the depth of twelve feet was communicated to the Society of Antiquaries of London in 1797, but not brought to general notice for more than half a century. Human bones associated with the bones of extinct animals had already been noted by several investigators, but to Boucher de Perthes belongs the real honor of first presenting Quarternary Man to the scientific world and the Valley of the Somme near Abbeville was the scene of his discoveries. About 1836, living at Abbeville, some 25 miles below Amiens, he began to make a study of geology and to collect the worked flints which he occasionally found in the old flood deposits of the river. In 1846, he published the result of his discoveries under the title "De l'Industrie primitive ou des Arts à leur Origine," but so revolutionary were these views towards the then generally accepted idea of the antiquity of the human race, that his publications and communications were treated with absolute indifference and unbelief by the most advanced scientific bodies.

Boucher however, continued his investigations and publications, and some years later was supported in his views by a former antagonist, Dr. Rigollot of Amiens, who in 1853 visited Abbeville and became convinced of the authenticity and significance of Boucher's discoveries. Dr. Rigollot began the study of similar gravels at Amiens and was rewarded by the finding of worked flints of different types associated with the bones of Quarternary mammals such as the elephas antiquus, the elephas primegenius or mammoth, a species of rhinoceros, a species of horse, etc. Still, little attention was paid to these discoveries by the French savants, but so persistent were they, that finally, in 1859–60, a number of the most prominent English geologists and archæologists, Prestwich, Falconer, Sir John Evans, Sir John Lubbock and others, visited Amiens and the Valley of the Somme, proved the Quartenary age of the gravels beyond a doubt, and themselves found many worked flints in place.

They were followed by a number of French scientists, and the fact of the existence of man in Quarternary times was thoroughly established in the scientific world.

A new impulse was thus given the subject, and new enthusiasts came into the field, old finds were viewed with renewed interest, and given a new interpretation. Henry Christy, an Englishman, and Edward Lartet, a Frenchman, associated themselves and became very prominent for their discoveries, Lartet particularly for his explorations of the now famous caverns and rock shelters of Dordogne in southwestern France.

The term "palæolithic" has been suggested by Sir John Lubbock to designate that period of man's development which was contemporaneous with the great Quaternary mammals and it has been generally adopted, as well as his term "neolithic" for the later stone age which followed.

Palæolithic man has probably descended from an ancestor living in the Tertiary period, but thus far no positive evidence of his existence has been discovered in any deposits or formations older than the second glacial period.

It is perfectly reasonable to suppose that man existed as man before this time, and indeed, the variety of types represented by the few skeletons, especially the skulls, which have been found belonging to Quarternary man make it difficult to escape from this belief. It is the same way as with the oldest languages of which we have any knowledge. No matter how old we may know the language to be or how simple its forms, we recognize that it is still too complex and varied to be a primitive tongue; that centuries and perhaps thousands of years of development have gone before in order to bring it to the comparatively complex form in which we find it. When in examining the skulls and other parts of the skeletons still preserved for us of glacial man, we find several distinct types, it can not be mere chance-these types signify distinct races, and different races of man in, dicate that a vast period of time has gone before, that ages have rolled away in order to make it possible for primitive man, the original Homo sapiens to have developed and evolved by environment and later by inheritance into the distinct races we find in glacial times.

If this is the case, if man existed in the preceding geological period, it is natural to suppose that some traces of him might be found; that if he aided himself by the use of stone implements as he would be likely to do, these tools, however crude, would some day come to light to reward the efforts of the archæologist and bear mute testimony of man's existence at that almost unthinkable antiquity. And already quite a series of objects have been discovered which although not yet distinctly proved, seem to give this looked-for evidence. Certain flints, thought by some to be the work of man, have been found in Tertiary deposits, notably those discovered by M. l'abbé Bourgeois, in 1867, at Thenay, in the department of Loire-et-Cher, France, and those brought to notice in 1877, by M. Rames, from a formation of similar age at Puy-Courny, Cantal, in the plateau region of Central France. These flints are very rough, and it has not yet been determined whether the chippings which they show are the results of intelligent work or are simply due to natural causes. Some of these flints show the action of fire as if they might have lain in old hearths as is often the case with worked flints of undoubted authenticity, but here again, there is no way of proving that the fire which has produced the calcined effect on the flint was not caused by some natural agency.

These tertiary flints which are sometimes known under the name of eoliths, have, on account of their uncertain character been the subject of considerable discussion and controversy. That they show human workmanship and are not simply natural forms is still undetermined. Flints showing undoubted traces of human agency in their shaping have been found in England, in Kent, in such positions or in such apparent relations to ancient deposits, as to make it possible that man may be certainly proved to have existed in times far more remote than those which saw the formation of the river drifts and cave deposits of western Europe. But the correlation of these flints with the more ancient deposits has not been certainly proved, and further investigation and detailed study of the question will be required.

Some of the other noted finds which seem to prove man's existence in Tertiary times may be briefly enumerated : The Savona skeleton, found in a Pliocene marl ; animal bones from the gravel pits of Saint Prest, from the Tertiary alluvium of the Arno Valley, and from the Pliocene of San Geovanni near Sienna. These bones, as well as those from other localities which it is not necessary to mention, show scratches, perforations, or fractures which have been claimed to be the work of man.

These few facts will suffice to show the nature of the evidence, otherwise than logical reasoning, which tends to prove man's existence in the Tertiary Period, and we will pass on to the succeeding age, when his presence, contemporaneous with the vast continental ice sheets and great extinct mammals is unequivocal and not to be denied.

At the present time, as has been before remarked, there is no positive evidence of the presence of man before the second glacial period, but the evidences of his existence from that time are numerous and unmistakable, and this great antiquity for the human race, however revolutionary and at variance to the beliefs still held by some, is as well proven and established as any of the common facts of science.

From this time on, we can keep man almost constantly in sight, through the different periods of his advancing civilization and culture. We can follow him through the long years of the different periods of the old stone age, until he had learnt the art of polishing his stone tools and weapons at the beginning of the present epoch ; through the Neolithic or late stone age, when the art of working stone reached its greatest and highest development, and was characterized by the fact they were often polished, an art unknown in the preceding stage of culture. Later, the use of metals became known, and we find man in the bronze age, with the ever increasing use of bronze instead of stone for his weapons, implements, and ornaments, and finally, with the coming in of the age of iron, if not in the latter part of the age of bronze, we find man in the realms of history and consequently far outside of our present field of investigation.

Let us look at the conditions which prevailed during Palæo-

lithic times and discover a little what was the life and civilization of these ancient people. While prehistoric archæology is giving us information of the civilization of these far distant ages, it is to geology that we must turn for our knowledge of the physical conditions which then prevailed. It is beyond the scope of our present discussion to consider the cause of the Ice Age, but we know that it took the place, in the Northern Hemisphere at least, of the exceedingly mild and even subtropical conditions of the period which preceded it. It was not an unbroken period of ice and snow, but rather an epoch of oscillation between severe conditions and those distinctly temperate and of much equability. The periods of severe conditions, which were rather times of great precipitation with moderate cold, than of remarkably low temperature, for the former seems more necessary to an ice age than the latter, reached their culmination in the so-called second glacial period, when all Northern Europe, including the British Isles, was covered with a vast, unbroken sheet of ice, and all the higher peaks and ranges sent their immense glaciers far down the valleys, and spread their morainic débris where are now fertile plains.

Geikie and other glacialists recognize six periods of the severe conditions, when glacial conditions more or less prevailed, with their corresponding interglacial periods of considerable mildness and equability. The third glacial period was nearly as severe and the extent of its glaciers nearly as great as during the time of maximum glaciation which preceded it. During the fourth, the great Baltic glacier obtained vast dimensions, but the last two returns to glacial conditions were very feeble, and represented the dying out of the Ice Age and the commencement of those physical conditions which we know to-day.

Of man's presence as far back as the second-interglacial period, there is not the least doubt. His tools, weapons, and implements, found in deposits of that age, in the undisturbed cave earths, mingled with the bones of extinct Quarternary animals, and covered deep under slow-forming stalagmite, in the diluvium of river valleys, and in other deposits, furnish unmistakable evidence.

In the dim ages of that remote period, man lived; clad in rough skins, he hunted the mammoth and the reindeer, where now are the green fields of Southern England and the vine clad slopes of France; and contended with the fierce cave bear, the hyena, and the cave lion for the protection and comfort afforded by the rock shelters and caves of Western Europe. Although rude and savage, he was capable of progress, as his implements of later and later date bear testimony. This has given a basis for the division by M. de Mortillet, of the Palæolithic Age into different periods according to the type of implement, each period having also its characteristic fauna.

Thus four periods are now generally recognized which are not always exact in their application, as a type originating in one, may and often does continue to be employed in those following, with the new types which there come into existence. These periods, which have come to be accepted for convenience in the study of the Palæolithic Age and as approaching as near to the truth as seems possible in any such classification, are as follows:

The Acheulian, the age of the old river deposits with such associated animals as the elephas antiquus, the mammoth, and the cave bear; the Mousterian, represented in the upper river deposits and the older caves, with the flourishing of the mammouth; the Solutrian, characterized by the highest development of stone implements, of the abundance of a species of horse, and of the reindeer; and finally, the Magdalenian, with its decline in the making and use of flint tools, and in its place, the great skill shown in the use of bone, with the remarkable development of art, which is shown by the engraved and painted rocks and engraved ivory and bones, which art seems to have entirely disappeared at the time of the ushering in of the Neolithic Age which followed. The fauna was characterized by the abundance of the reindeer and the European bison, the auroch, an animal nearly extinct but still preserved in some o the imperial forests of Russia.

As the third glacial epoch reached its culmination, Palæolithic man seems to have retreated southward, occupying the

rock shelters and caves of Central and Southern France, of the Pyrenees, and along the shores of the Mediterranean, but when the severe conditions of that time came to an end and the climate improved, there seems to be no evidence that he moved back to his old haunts and hunting grounds, but passed eastward into Switzerland and the region about the headwaters of the Danube and the Rhine.

From this time on, we lose sight of Palæolithic man, there is no trace of him to be found in any deposit which overlies or is more recent than the accumulations of the third glacial epoch. Beyond this, before man reappears at the beginning of the Neolithic age, there seems to be a gap, a considerable interval of time in which he is entirely lost from sight. In almost every series of deposits containing the remains or implements of both Palæolithic and Neolithic man, there is a sterile layer of greater or less thickness which separates the two; sometimes it is a stalagmite floor of considerable thickness and representing a great period of time. Man must have been somewhere, evolving and developing, and acquiring the arts and culture with which we find him when he again appears at the beginning of the Neolithic, and some deposit in some region will one day reward the labors of archæologists by filling in this gap, if it has not already done so, in some of the more recent discoveries.

Before closing our brief investigation into the subject of Palæolithic man, it will be well for us to realize his great antiquity, the immense period of time which has rolled away since we first find him, hunting the mammoth and the reindeer with his rude flint weapons, and seeking refuge in the old caves and rock shelters of that remote period.

The tourist looks with awe upon that megalithic monument or Salisbury Plain on account of its great antiquity and the unknown people who built it, but it is certainly not older than the Bronze Age and does not antedate the Roman Invasion of England more than 1700 years. Even the oldest tombs and temples of Egypt are modern compared with the rude implements from the river drifts of the Somme, the Seine and the Thames. There has been no considerable change in the physi-

cal features of the country since Stone Henge or Avebury Circle were built, or the alined stones of Carnac placed in position, but Palæolithic man saw great geological changes which must represent a vast extent of time.

Valleys were eroded to great depths during the period in which he lived, while rivers which are now but a few hundred feet across, he then saw as swollen floods two miles or more in width. The slow movements of the earth's crust by which whole continents are raised and lowered, enabled him with the animals he hunted, to pass dry shod between the continent of Europe and the British Isles, and this great but slow change in the physical outline of Europe took place more than once since that time when Palæolithic man first made his undoubted appearance.

He lived through the vast period of time represented by the slow coming on of glacial conditions, the formation of a great continental ice sheet over all northern Europe, and the return once more to a milder climate with all the changes of fauna and flora these imply.

We cannot tell the length of time in years, it may be fifty thousand, it may be more, but by the immense physical changes which have taken place, we know it must be very great, and not to be reckoned as history reckons her time.

Such is a brief outline of Palæolithic man, of our ancestor in Quarternary times, and here we will leave him and close this paper.

[ANNALS N. Y. ACAD. SCI., VOL. XVI, No. 3, pp. 75-81, March 17, 1905.]

HENRY CARRINGTON BOLTON.

DANIEL S. MARTIN.

Dr. Henry C. Bolton, our late associate and ex-President, was born in this city, January 28, 1843, and at his death in Washington, November 19, 1903, had therefore not completed his 61st year. After graduating at Columbia University in 1862, he went to Europe, and studied first in Paris, subsequently at Heidelberg under the celebrated Bunsen, and later at Gottingen, where he received his doctorate of philosophy in 1866. During these years he also travelled extensively, adding to his favorite specialty of chemistry that store of varied culture that made him such an attractive companion and broad-minded scholar and gentleman.

On returning to New York, he naturally associated himself as a member with the Academy (then the Lyceum of Natural History), and speedily became active in its meetings. In 1872 he was made assistant in analytical chemistry in the Columbia College School of Mines, and then head of the laboratory of quantitative analysis ; this position he held until 1877, when he was chosen Professor of Chemistry and Natural Sciences in Trinity College, at Hartford, Conn.

These were years of constant activity in the Academy and in many scientific associations in and about New York. In 1874 he was one of the special committee who formulated the report on the change of name of the Society, from the Lyceum to the Academy. In 1876 he was elected Corresponding Secretary, a position for which he had peculiar fitness, from his elegant handwriting and his familiarity with the languages and the scientific men and institutions of Europe.

In 1873 he was one of the most active in planning and arranging for the "Centennial of Chemistry," held at North-

umberland, Pa.; where all the chemists of the United States gathered at the home of Priestley and his descendants, to celebrate the hundredth anniversary of the discovery of oxygen gas.

After ten years at Hartford, where Dr. Bolton left his permanent impress in the formation of a notable collection of minerals for Trinity College, he resigned and returned to New York. It is characteristic of his generous nature, that he left that position with the expression that, being possessed of independent means, he did not feel that he ought to retain the place of a salaried professor, so desirable for some other worker in science not favored with his resources. Let no one imagine from this that he sought for ease and leisure. No man was ever a more tireless worker; his fertile brain and his all-around scholarship could brook no respite. He simply gave himself to other lines of scientific acivity, which he made peculiarly his own.

He had become especially impressed with the difficulties presented to the chemical investigator by the vast and ever-increasing body of literature in that and in allied departments, in many languages, and scattered through a multitude of journals, transactions and periodicals. This he sought to relieve by some form of systematic recording; and after conducting a series of investigations of great care and beauty upon fluorescent bodies, and particularly the uranium compounds, for which he had gathered and collected all that had appeared on these subjects, he published in the Annals of the Lyceum his "Index to the Literature of Uranium," in 1870. This was the first of a series of such indexes to the entire literature of single elements and of special topics in chemistry, which have now become very numerous and of indispensable utility. Dr. Bolton presented this subject to the Section of Chemistry of the American Association for the Advancement of Science, and in 1882 secured the appointment of a permanent committee of that body on the indexing of chemical literature. Of this committee he was the ever-active chairman; and the annual reports of progress for over twenty years indicate the growth and the scope of the work that he had thus inaugurated and carried on.

In the meantime he had become engaged himself in a similar and even more comprehensive labor, — a general historical compendium of chemical literature, in all languages, and of every kind. This great undertaking he carried out in connection with the Smithsonian Institution at Washington. In 1892, he was appointed by Columbian University of that city to a non-resident professorship of the History of Chemistry; and it was not long before he moved to the capital and made his residence there. He had recently married Miss Henrietta Irving, a grand-niece of Washington Irving; and many of his former friends from this vicinity are familiar with his refined and attractive home on K Street. Here, with his remarkable library and rare works on alchemy and chemical history, and in close touch with all the scientific life of the Federal city, he labored with unfaltering zeal and enthusiasm until the recent end of his career.

During the decade of his second residence in New York, before he removed to Washington, he was again active in the Academy, and was chosen to several offices, culminating with that of President in 1893. He was one of the patrons of the Academy by the contribution of a hundred dollars. Besides his relations with this society, he was prominent in chemical circles, both in this country and abroad, and a very frequent lecturer and contributor to scientific journals and reviews. At the time of his death, the statement was made that he belonged to more learned societies than any other American.

Dr. Bolton was a man of very marked personality and of peculiar qualities of mind, which fitted him for a peculiar work. He was a thorough and accomplished chemist, but he was very much more than a specialist in any one department. He was a man of letters and of culture in every field, and one who possessed a fine æsthetic sense and in a remarkable degree the historic sense. It is easy for those of us who knew him and have followed his career, to see how all these elements were blended in his work. Favored also with the possession of private means, he was able to follow out the bent of his mind, and to add continually, by frequent and extensive travel and intercourse, to his rich and varied store of refined culture. Wher-

ever he went he was the same, — the genial and warm-hearted friend, the gentleman, the scholar, the scientist, the litterateur; his mind was ever on the alert to discern and to investigate novel and peculiar points of interest that others failed to observe, or to hear the forgotten voices of early workers from the morning twilight of science, that are now lost to common ears in the noise of the modern "gairish day." No ordinary man, no ordinary chemist, could ever have done his work. Some have indeed said that he failed to do what he might have accomplished had he given himself more closely to original investigation, and confined his activities within a more limited range of study. This may be true, in a sense, but only in a narrow sense. There are many men capable of original investigation, who could never attain, either by natural qualities or by acquired experience, to the breadth and scope of Dr. Bolton, or to the work which he accomplished.

He was imbued, as I have said, with the historic sense in an unusual degree; and this made him especially an historical chemist and a chemical historian. He loved to recall the labors of the pioneers in science, and to recognize their part — crude as it may seem to us now — in the development that has followed. As early as 1876, in an article in the "American Chemist," he expressed the key-note of much of his subsequent work in the following words: "So rapid are the strides made by science in this progressive age, and so boundless is its range, that those who view its career from without find great difficulty in following its diverse and intricate pathways, while those who have secured a footing within the same road are often quite unable to keep pace with its fleet movements and would fain retire from the unequal contest. It is not surprising, then, that those actually contributing to the advancement of science, pressing eagerly upward and onward, should neglect to look back upon the labors of those who precede them and should sometimes lose sight of the obligations which science owes to forgotten generations." But it was not only either from, or for, the historic interest purely, or mainly, that Dr. Bolton began his great work of chemical indexing and bibliography. He felt

the need of the modern worker for help and guidance in his researches, and sought thus to supply it. He inaugurated in this a monumental work, which should win for him the gratitude of every special investigator in chemistry. He began this work himself, and the first indexes, by him and by others inspired by him, appeared in the Annals of this Academy. It has subsequently grown to great expansion and variety, largely through his committee in the American Association; and now it will go on, though, alas! other hands must direct its progress. His next step, also begun in the Annals of this society, was his "Bibliography of Chemical Periodicals," in all the languages in which they are published. This led on to the herculean task that occupied all his later years in Washington, and which he was fortunately able to complete. These great works are "A Select Bibliography of Chemistry, 1492 to 1896," and "A Catalogue of Scientific and Technical Periodicals, 1665 to 1895"—together with extended supplements, bringing down both of them to very recent dates. They will long remain as his grand memorial.

To a mind like Dr. Bolton's, the subject of alchemy and the old traditions and superstitions connected with it, could not but appeal with great interest; and he was noted for his familiarity with those topics and with many very curious related aspects, on which he published numerous articles. The strange survivals, and even revivals, of alchemistic fancies in the modern world, led him naturally to an interest in folk-lore; and he was active as an officer in the organization of the American Folk-Lore Society. His restless and suggestive mind was ever leading him to explore peculiar and unfamiliar paths, and to turn aside from the beaten tracks that most of us are either content or constrained to follow, into byways that lead off into near and yet unknown places where few or none have trod. An instance of this kind was his research upon sonorous or "singing" sands, carried on through years, largely in connection with our honored member, Dr. A. A. Julien, and in which he traveled widely and gathered material from many lands and seashores, and showed that this phenomenon, still essentially unexplained,

is somewhat frequent rather than very rare, and is not at all dependent upon several of the causes to which it was formerly ascribed.

In original investigation in chemistry, however, Dr. Bolton was capable of excellent work, although this was not his most important field. His early researches have already been in part alluded to, on fluorescent compounds of uranium, and also on the platino-cyanides. In both these groups he prepared a large number of rare and novel compounds, crystallized with great success and great elegance.[1] His subsequent studies upon the action of organic acids on minerals and "The Behavior of Natural Sulphides with Iodine and other Reagents," were highly original in character and of much interest. They appeared in the Annals of this society, in several successive papers, while Dr. Bolton was professor in Trinity College; and it is interesting to recall that the first of these was Article I in Volume I of the Annals of the N. Y. Academy of Sciences — after the change of name from the old Lyceum.

I cannot in a brief article like this, begin to do justice to the memory of one whom I knew so well and esteemed so highly; we came forward together in the Lyceum, and worked together as fellow-members, friends and officers, in close and constant association for many years in the Academy. It only remains for me to add that Dr. Bolton in his personal views and feelings was a reverent Christian believer — a scientist who knew too well the limitations of human experience and attainment, the mutability of human philosophies and conceptions, and the vastness of the field of the unexplored and unimagined that surrounds our science on every hand, to doubt or deny the reality of the spiritual and the unseen. Three years ago, on retiring from the office of President of the Chemical Society of

[1] This beautiful and remarkable series of uranium salts, which Dr. Bolton had given to the Columbian University, was loaned by that institution to form one of the exhibits in the radium display organized by the U. S. Geological Survey at the St. Louis Exposition. The writer called the attention of the Special Commissioner in charge of the radium display, Mr. George F. Kunz, to this collection, and it was thus secured as an interesting contribution to that notable feature of the Fair.

Washington, he delivered an address entitied "Physics and Faith," in which he pointed out most forcibly how the doctrines of physics and chemistry depend equally with revelation on belief in the invisible. I close with a few of his own words: "Faith, both in science and religion, is belief based on suitable evidence from sources outside of personal experience; both are fruitful in different ways, the former affecting the intellect and the latter the heart of man; scientific faith bears fruit in the steamship and the telegraph, Christian faith in works of mercy and charity, and in a life of love shown toward mankind and God."

[Annals N. Y. Acad. Sci., Vol. XVI, No. 4, pp. 82–95, March 17, 1905.]

THE JURASSIC COAL OF SPITZBERGEN.

John J. Stevenson.

(Read January 14, 1905.)

The Spitzbergen archipelago, consisting of five large and many small islands, extends from N. Lat. 76° 30′ to 80° 30′ and lies about midway between Nova Zembla and Greenland, while the southern point of the principal island, West Spitzbergen, is about three hundred miles north from the North Cape. The greater part of the archipelago is inaccessible for shipping except in rare seasons, as a cold current brings down the ice along the northern and eastern portions ; but the western coast of the main island is accessible ordinarily during about three months each year. Until less than a century ago, little was known respecting Spitzbergen beyond the information brought by whalers, of whom William Scoresby was easily chief. The first systematic exploration was by the Norwegian geologist, Keilhau, who, in 1827, studied West Spitzbergen as well as the lonely Bear island, one hundred and fifty miles southward, and made collections, described in part by von Buch in 1846. A French expedition of 1839 gave notes upon the islands, some of which are of interest. The most important contributions, however, are those of the Swedish geologists, whose studies began before 1860 and have continued at frequent intervals until within ten years, their results being published for the most part by the Stockholm Academy of Sciences. Prof. Franz Toula of Vienna visited West Spitzbergen in 1873 and made important observations upon the Carboniferous.

West Spitzbergen extends from N. Lat. 76° 30′ to 79° 55′ and is indented deeply by bays, of which the most conspicuous are Kings and Cross, with common outlet at 79°, the long Ice-

fiord, 78° 10′, extending inland to 78° 50′, with numerous bays, Dickson, Klass Billen, Sassen and Advent, and Bell's sound, 77° 30′, with Lewis sound and Recherche bay as its principal divisions. All of these are more or less accessible from the middle of June until some time in September.

This ready accessibility of the west coast has encouraged attempts to utilize the mineral resources. Many years ago a deposit of phosphates was discovered on Icefiord but the effort to work it proved to be unprofitable. Coal was discovered almost one hundred years ago in the northern portion on Kings bay, where it was mined by Dutch whalers. Keilhau found coal on Cross bay in 1827 and in 1861 Bloomstrand rediscovered the deposit on Kings bay, the glacier concealing it having retreated. He traced the bed for 7,000 feet but was unable to ascertain its thickness though he determined that the coal is brilliant, with conchoidal fracture, burning completely to ash and showing here and there some woody structure. The associated plant remains were long leaves and stems of deciduous plants.[1]

Von Buch cites Robert as an authority for the statement that whale fishermen had taken sixty tons of coal from Icefiord to Hammerfest, evidently prior to 1839; and he says that *Calamites*, *Sigillaria* and even *Lepidodendron* are not of rare occurrence in these coals.[2] The Swedish expedition under Nathorst and DeGeer in 1882 studied very carefully the deposits on Icefiord and Bell's Sound. They succeeded in rediscovering a coal horizon on Advent Bay, but were unable to determine whether or not it is of workable thickness. An important collection of plants made in that year by Nathorst and described by him in 1897, enabled him to determine the age of the deposit as upper Jurassic.[3] It is certain that the Carboniferous plants

[1] Bloomstrand's publication in the *Trans. of the Stockholm Academy* is not accessible to the writer and the reference is taken from F. Mohr, Geshichte der Erde, 1866, pp. 128–9.

[2] Robert, *Bull. Soc. Geol. du France*, xiii, as cited by von Buch, *Berlin Akad. des Wissenschaften*, May, 1846, p. 73.

[3] A. G. Nathorst, "Zur Mesozoischen Flora Spitzbergens," *Trans. K. Svenska Vetenskaps Akad.*, Band 30, No. 1, pp. 5, et seq.

mentioned by Robert, as cited by von Buch, must have been collected at some other locality and not in association with coal, as no coal occurs in the Carboniferous of Icefiord.

Carboniferous rocks do exist in West Spitzbergen, and the map given by Nathorst shows extensive areas of these rocks on several branches of Icefiord as well as on Bell's sound and further south. In 1827 Keilhau obtained *Spirifer keilhavii* from the South cape and in 1839 the French expedition collected the same spirifer with *Productus giganteus* from Bell's Sound. Toula in 1873 found a Carboniferous fauna in the northern portion of Icefiord, which shows a commingling of Permian and Coal Measures forms much like that existing in Nebraska and West Virginia. Nathorst has described recently the Carboniferous plants collected at several localities on Icefiord and Bell's sound, referring them to the Lower Carboniferous.

Thus far no workable coal bed has been found in this formation on Spitzbergen. Coaly streaks are present at some of the northern points along Icefiord but they are not beds. Last year, Mr. G. A. Fangen found on Recherche bay of Bell's sound, about five miles below the anchorage, a bed of excellent coal, four to five inches thick and associated with a dark shale showing abundant impression of plants. The outcrop is covered with débris and the stay at this locality was too brief to admit of uncovering the coal and its plant bed. It seems to be near the spot at which Professor DeGeer observed Lower Carboniferous plants. The absence of workable coal in southern Spitzbergen at the bottom of the Carboniferous is the more noteworthy because coal is present on Bear island, N. Lat. 74° 30′, which was discovered in 1684 by Bennet, who took some of this coal to England. In 1827, Keilhau found four coal beds in a vertical section of about 200 feet, the intervening rocks being fine grained sandstone. Higher beds, unquestionably of Coal Measures age, are here as shown by the mollusks, and von Buch was inclined to place the coals in the Lower Carboniferous, which would make them equivalent to the plant beds of Spitzbergen.[1] Professor Nathorst, however, made

[1] Von Buch, op. cit., pp. 67, 73.

collections on Bear island in 1898 and still later additional collections were made by Doctor J. G. Anderson, all of which were described by Nathorst in 1902.[1] The study of these plants led him to refer the beds to the upper Devonian. The shallow water between Spitzbergen and Bear island suggests a land connection between the two areas until comparatively recent times. The Bear island coal field must have extended much further south and west, for even since the glacial period the island has lost much on those sides, the glacial trough now on the westerly side of the island having lost the greater part of its west wall and the cirque on the southerly side has been removed.

The coal beds on the east side of Advent bay are placed by Nathorst in the upper Jurassic. During the last decade spasmodic attempts at mining have been made, chiefly to supply the whalers who ply their trade by means of steam launches. The whole region was explored in 1903 by an English-Norwegian company and in 1904 that company began systematic development on the east side of Advent bay. At the time of the writer's visit, the work in charge of Mr. G. A. Fangen, M.E., of Bergen, was advanced sufficiently to exhibit the coal and the conditions of its occurrence.

The opening is at perhaps a mile and a half from the mouth of the bay and at 330 feet above the water. Mining was begun early in June with the expectation that it could be continued until late in September, when a shipment of about 1,000 tons might be made to Tromsoe in order to make a thorough comparative test with the English coal used there. The main heading had been driven sixty yards from the crop and a room had been opened, extending perhaps twenty yards northward to another heading, which has been abandoned. The section of the bed is

	Feet.	Inches.
1. Coal	0	4
2. Parting		
3. Coal	0	5

[1] A. G. Nathorst, "Zur Ober-Devonian Devonischen flora der Bären Insel,' *Trans. K. Sven. Vetens. Akad.*, Band 36, No. 3.

	Feet.	Inches.
4. Parting		
5. Coal	0	11
6. Clay	0	2 to 4
7. Coal	1	7
8. Rock, sandy	0	3 to 5
9. Coal	1	0

The measurements are exact only for the place at which they were made and the portion, Nos. 1 to 5 inclusive, averages not more than 1 foot 3 inches. The whole of the coal is mined, but the character is not the same throughout. The "top," that above No. 8, is hard, grayish black, with fracture more or less conchoidal and much like a splint coal; the "bottom" is black, lustrous, with layers of brilliant coal and a somewhat prismatic structure. It is tender and shows some mineral charcoal, but this is not abundant. The composition is shown by the following analysis, for which I am indebted to the courtesy of Mr. Andrew S. McCreath, so long the chemist of the Second Geological Survey of Pennsylvania, who has added this to the series of similar favors for which I am under obligations to him.

"The two samples of Spitzbergen coal yield on analysis respectively:

	Top.	Bottom.
Moisture	3.310	4.696
Volatile matter	19.790	28.560
Fixed carbon	62.763	57.171
Sulphur	.467	.413
Ash	13.670 (gray)	9.160 (light brown)
	100.000	100.000

"The ratio of fixed carbon to volatile matter differs considerably in the two coals; but three determinations were made in each case. Such a difference has already been noted between the coal of the upper and lower benches, but it is unusual; and generally the coals in a vertical section show approximately, at least, the same ratio of volatile matter to fixed carbon. (See Survey Report, MM, pages 94 to 97.)

"The coals yield gases burning with a luminous but feebly smoky flame, and neither of them shows the slightest tendency to form a coherent coke.

"Both coals seemed to be quite dry, that is, free from hygroscopic moisture and yet the percentage of moisture at 212° F. is quite high in both coals. This is suggestive that either the samples represent outcrop coal — where, owing to some peculiar physical change in structure, the 'dry' coal may yet hold an excessive amount of moisture and have its coking qualities (if it ever had any) entirely destroyed or to a different kind of vegetation forming the coal. In the present case the action of caustic potash solution has a marked effect on both coals, but more noted in the bottom coal, where the action is so marked as to suggest a lignite or a coal of such character or origin."

Mr. McCreath's reference to the difference in volatile, shown by the two portions of the bed, is too important to be passed over. The relations are, ash and moisture being neglected,

	Top.	Bottom.
Volatile matter	23.9	33.3
Fixed carbon	76.1	66.7
Fuel ratio	1 : 3.17	1 : 2

giving a difference of somewhat more than 9 per cent. This is considerably more than the usual difference; commonly one finds not more than 2 or 3 per cent. though in a few of Mr. McCreath's analyses it reaches 5. The especial case to which he makes reference is that of a coal bed at a mile and a half east from Bernice in Sullivan county of Pennsylvania, whose two branches, according to his analyses, show

	Upper.	Lower.
Volatile matter	28.36	12.61
Fixed carbon	71.64	87.39
Fuel ratio	1 : 2.52	1 : 6.93

At Bernice, a bed at very nearly the same horizon, possibly the same, shows practically no variation in the benches and the average ratio of several analyses is almost 1 : 9, closely approaching anthracite. In this connection note should be made of another fact shown by Mr. McCreath's analyses. At sixty feet below the Bernice semi-anthracite bed, is coal which has the ratio of 1 : 4.63, while at six miles southwest, a still lower

bed yields coal with the ratio of 1 : 2.52, the same with that from the upper bench of the bed east from Bernice.[1]

More remarkable are the differences existing in the benches of the Mammoth coal bed within the anthracite region at the Locust Spring and Indian Ridge collieries of the Philadelphia and Reading company, as shown by the analysis of Doctor C. M. Cresson, made for that company. At Indian Ridge the extremes are

Volatile matter	3.2	10.42
Fixed carbon	96.8	89.58
Fuel ratio	1 : 30.2	1 : 8.6

and at Locust Spring

Volatile matter	1.89	15.3
Fixed carbon	98.11	74.7
Fuel ratio	1 : 52	1 : 4.88

Other benches show ratios between those quoted. In four other collieries belonging to the same company, the differences between the several benches are insignificant.[2]

The varying proportion of ash has no bearing upon the difference in volatile. At Advent bay, the upper bench has the higher ash and lower volatile; but near Bernice the high volatile of the upper bench is associated with nearly five times as much ash as is found in the lower bench; at Locust Spring, the bench richest in volatile is high in ash while another at seven feet lower has almost the same ash but less than one fourth of the volatile. Similar conditions exist at Indian Ridge. Nor has the relative position of the benches any influence. At Advent bay, the lower bench is the richer; near Bernice, the upper; at Locust Spring, the highest bench of the mammoth is the richest, while at Indian Ridge the highest volatile is found midway in the bed. The difference in physical features brings no explanation for coal in Virginia, analyzed by Mr. McCreath and very closely resembling the top coal of Advent

[1] A. S. McCreath, Reports of Second Geol. Surv. Penn., MM. pp. 94–97. Ann. Rep. for 1885, p. 318, GG, p. 214.

[2] Ann. Rep. Sec. Geol. Surv. Penn. for 1885, p. 321.

bay, is very rich in volatile. The cause of the difference must be sought in conditions existing during the accumulation of the coaly matter, chief among which must be the length of exposure to the influences bringing about continued combination of carbon and hydrogen to pass off as marsh gas.

The coal obtained for analysis is not "crop coal." On Advent bay it has not been exposed to variations in temperature and moisture which are so efficient in causing deterioration of coals in our latitude. It was frozen long ago, before the present configuration of the valley was completed and it has remained frozen ever since. The temperature in early August, at no time rose above 39° F. The land surface is boggy in great part and is covered in many places by lowly flowering plants, but the summer thaw reaches to only a few inches below the surface. There is not the alternation of freezing and thawing so destructive to crop coal in our climate. The condition is well shown in the Fangen mine where at 180 feet from the crop and somewhat more below the top of the rock bench, ice was found covering the rock in the heading. Yet the temperature outside had seldom fallen below freezing after the mine was opened. In the original heading, now abandoned, ice was reached along a fault line, fifty feet from the crop and it continued to the end of the heading. The explanation of the moisture must be sought elsewhere. At the same time, it must not be forgotten that the moisture in the Advent bay coals, though three to four times as great as that usually found in the bituminous coals of Pennsylvania, is not higher than that of many coals from Ohio, while it is much less than that in most of the Iowa coals. The great majority of analyses from the last-named State show upwards of six per cent. and not a few show ten per cent. and upward — all of these being carboniferous.

The reaction of the coal with caustic potash suggested other comparisons. Mr. Norman A. Dubois, Instructor in Quantitative analysis at New York University, very kindly analyzed the coal from the lower bench with the following result:

Moisture	4.14
Carbon	67.88

Hydrogen	4.05
Oxygen and Nitrogen	11.90
Ash	12.03

The ash is higher than Mr. McCreath's analysis because the latter was made from the lump coal while the coal for this was fine coal. The nitrogen is present in small proportion, considerably less than 1 per cent. and it was not determined separately.

The Fangen coal from Spitzbergen, wholly non-caking, is attacked by caustic potash very energetically even in the cold. For comparison, several non-caking coals were tested. The lignitic coal of Carbon, Wyoming, Laramie in age, resembles in color the upper bench but in structure the lower bench of the Fangen bed; that from Rock Springs, Wyoming, also of Laramie age, has a fracture like cannel, and, unlike the Carbon coal, shows no mineral charcoal. These coals are attacked slowly in the cold but very rapidly at the boiling temperature. A non-caking coal from Des Moines, Iowa, of Coal Measures age, is attacked notably in the cold and almost as rapidly as the Fangen coal at boiling temperature. This coal is very like that from Carbon, but has more mineral charcoal and contains upwards of 6 per cent. of water.

A coal from Savanna, Indian territory, of Coal Measure age, and yielding an inferior coke, is attacked slowly in the cold and the solution becomes distinctly tinted after prolonged boiling.

Several caking coals were tested; they are from Canon City, Colorado, and Madrid, New Mexico, of Fox Hills age; Starkville, Colorado, of Laramie; Vancouver's island, of Upper Cretaceous; Leavenworth, Kansas, Wolf county, Kentucky, Fayette and Westmoreland counties, Pennsylvania, of Coal Measures. Not one of these caking coals caused the slightest discoloration of the solution after ten minutes of boiling.

In both classes are coals of Carboniferous and Cretaceous age, coals made under similar conditions of cover and similar relations to disturbing agencies, so that one is led to suspect that the character of the coal was determined very soon after burial.

Ultimate analyses of the coals referred to are not available in most cases, but a few can be given. They may be tabulated as follows:[1]

	H_2O	C	H	O	N	Ash.
1. Fangen	4.14	67.88	4.05	11.90		12.03
2. Carbon	7.35	63.65	4.60	19.44	1.40	2.80
3. Canon City	6.59	70.64	5.13	10.79	0.97	5.30
4. Starkville	0.44	73.58	4.81	9.41	0.31	10.80
5. Connellsville	0.89	82.48	4.50	5.61	1.45	4.13

The roof at the Fangen mine is a black slate, but throughout it is frozen so that none of it has been taken down. No plant impressions were observed in any of the little fragments that had fallen nor had any been seen by the superintendent or the foremen.

To secure a complete section of the rocks, to the top of the bluff, fully 1,600 feet, would be extremely difficult owing to the abruptness of the face. If one may determine from a somewhat close examination of the loose fragments up to about 400 feet, the result of the effort would hardly repay the labor. The softer beds are concealed by débris except in some precipitous portions, while the exposed rocks are flaggy sandstones. Evidently, one has here a succession of brown, gray, reddish and yellow flaggy sandstones and sandy shales with apparently some streaks of black shale. But from the palæontologist's standpoint the detailed section might prove of great interest. Professor Nathorst collected from a ravine near the head of the bay the interesting series of plants, *Tæniopteris*, *Lycopodites*, *Baiera*, *Feildenia* and *Elatides*, which enabled him to determine the age of the beds as Upper Jurassic. These remains were found in a black shale, but they are not confined to that stratum, for Mr. D. H. Morris, accompanying the writer, obtained among other specimens a block of sandstone with *Tæniopteris* from a

[1] No. 2 is by C. E. Munsell, *Jour. Amer. Chem. Soc.*, xiii, 4. Nos. 3 and 4 by R. C. Hills, Min. Res. U. S., 1892, p. 362. No. 5 by J. L. Lilienthal, unpublished, communicated by Prof. J. F. Kemp. The writer will present the results of studies upon this matter and others bearing on the variations in coal at a later time.

ravine toward Sassen bay. A sandstone fragment, obtained by the writer on the bluff along the east side of Advent bay, shows an imperfect mould of an *Astarte* which Dr. R. P. Whitfield thinks related to a Cretaceous form found in the Rocky mountain region. Curious ferruginous concretions are abundant and the sandstones often bear markings similar to those long regarded as fucoids.

The beds are evidently conformable throughout, but they are not undisturbed. The general dip is N. 30° W. Mag. (error 15° W.) at the rate of three feet per hundred. Faulting is not infrequent. The original heading at the Fangen mine reached at somewhat more than fifty feet a downthrow fault, which was followed for nearly thirty yards before the work was abandoned. The crushing along the fault is slight and the throw, as is seen in a hard sandstone above the crop, does not exceed six feet. Other faults were observed in the face of the cliff, but they are all insignificant.

The coal bed opened by Mr. Fangen is not the only one. The outcrop of another is distinct at perhaps three hundred feet below the crest, which Mr. A. E. Stevenson found on the opposite side of Advent bay to be 1,600 feet (by barometer) above the water. This bed is of workable thickness, but at present it is practically inaccessible, being about 1,300 feet above the shore. Traces of an intermediate bed were seen, but nothing has been ascertained respecting it.

The coal has been traced around the face of the cliff along Icefiord to and along Sassen bay, a distance of more than ten miles; and Mr. D. H. Morris, following a ravine between Advent and Sassen to its head in the plateau, found fragments of coal along the whole distance. The outcrop of the lower bed is thoroughly distinct to the head of Advent bay on this easterly side. A coal cropping appears on the westerly side at a little way above the anchorage, whence croppings were followed to Icefiord and for some distance along the southerly shore. Coal is mined in a ravine coming down almost to the anchorage and an abandoned opening was seen at almost a mile further northwest, where a Holland company had marked out a claim. Pro-

fessor Nathorst is inclined to refer the coals on the westerly side to the Tertiary; but there seem to be no differences between the rocks on the two sides of the bay; the sandstones bear the same markings and the curious ferruginous concretions are as characteristic on the westerly as on the easterly side. Collections made by D. H. Morris and A. E. Stevenson on the plateau between Advent and Coal bays, a distance of about ten miles, as well as along the southerly side of Icefiord between those bays, show the same features throughout; so that one appears to be justified in regarding all as of the same age and in referring all the coals of Advent bay as well as that on Coal bay to the Jurassic, in accordance with Professor Nathorst's determination for the beds on the easterly side.

While, along the line followed by Messrs. Stevenson and Morris, only Jurassic beds were seen, it is necessary to go eastward but a short distance to reach Tertiary beds, of which some knobs remain well-marked at not more than seven miles from Advent bay. These flaggy, grayish standstones are loaded with leaves of dicotyledons, with which occur stems of horsetails and apparently leaves of cycads. The succeesion throughout appears to be conformable and the passage from Jurassic to Tertiary seems to be very gradual.

The effort to mine the Fangen coal in commercial quantities, if successful, will be of more than passing interest. The market is ample in northern Norway, where the coal can be placed at less cost than that from England. The long wintry night and the closing of the harbor by ice during nine months each year seem almost prohibitory. But the company, in case the test be satisfactory, purposes to make new openings at a more favorable point further up the bay, to erect comfortable dwellings and to instal a complete electric plant, so that the work may continue uninterruptedly throughout the year. The proposition is by no means chimerical, as some might suppose. The average January temperature is said to be not lower than 15° F. and evidently Advent bay is less cold than other places not more than a few miles away. On the northerly side of Icefiord, about eight miles from the Advent bay anchorage, a continuous

glacier extends for more than ten miles, from Cape Bohemian to Alk point; ice was present during August, 1904, in bays further up Icefiord, yet around Advent bay and in the long Advent dale, extending southward from that bay, there was no ice except in some sheltered ravines where petty glacierets remain.[1] The ill-success of attempts to winter on the island were not due to the severity of the climate for Russian tribes wintered there during many successive seasons. Scurvy, not the climate, made wintering impossible for Europeans. That terror no longer exists.

One must not fail to note that the general conditions during accumulation of the Spitzbergen coal did not differ from those during the accumulation of coals in our land. Even the intermittent deposit is proved by the lamellar partings as well as by the thicker rock parting. The climatic conditions from Carboniferous to Tertiary were like those of lower latitudes. Nathorst says of the Carboniferous, "The plants already known in Europe are in Spitzbergen as great as here, Ferns, Lepidodendron and Sigillaria." Toula discovered a familiar fauna in portions of the Icefiord area, as did also Keilhau and the French explorers in the southern part of the island; the Jurassic flora is of a type familiar in Europe, while the later flora abounds in deciduous plants.

Reference to the occurrence of seaweeds along the Spitzbergen coast is not out of place here. It may be remembered that Mohr, forty years ago, asserted that coal beds are due to accumulation of seaweed material and found a strong support for his theory in the existence of coal on Spitzbergen. He quotes from some writer in the bulletin of the French Geological Society and also from Naumann the statement that "Even now there flourishes on the Spitzbergen coast a so luxuriant Fucus vegetation that often the boat can scarcely work its way through." [2] He regards the Gulf Stream as the great carrier of material and as responsible for the existence of the weed. There is no room

[1] It may be stated in passing that the glaciers of southern Spitzbergen are clearly decreasing.

[2] Mohr, *op. cit.*, p. 130.

for doubt that the great northward drift has some influence on the climate of West Spitzbergen, for the conditions along the westerly shore are much more tolerable than those on Bear island, 150 miles south, but exposed to a southward drift. At the same time the conditions are not such as Mohr supposed, for he seems to have imagined the surface densely covered as in the Saragasso sea. For 150 miles along the west coast, the water during August of 1904 showed few and small patches of seaweed and the amount stranded on the shore is utterly insignificant; so that even had there been a Gulf Stream during the Jurassic, its seaweed would not have been an important factor in coal-making.

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[Annals N. Y. Acad. Sci., Vol. XVI, No. 5, Part II, pp. 97–152, March 18, 1905.]

ESSAY ON THE GRAMMAR OF THE YUKAGHIR LANGUAGE.

Waldemar Jochelson.

Contents.

PREFACE.

I took up the study of the two dialects of the Yukaghir language in 1895–97 during my participation in the Yakut Expedition, fitted out by the Russian Imperial Geographical Society, and continued it on the North Pacific Expedition (from 1900 to 1902), provided for by Mr. Morris K. Jesup, President of the American Museum of Natural History in New York. My work on the Jesup North Pacific Expedition was part of a general systematic investigation of the tribes inhabiting the coast of the North Pacific Ocean. The full results of these studies will be published later on in the Memoirs of the American Museum of Natural History.

All that was previously known of the Yukaghir language consisted of records of a few hundred words and sentences collected incidentally by various travelers and Russian officials, particularly by Baron v. Maydell (1870), and worked up by the late Professor A. Schiefner in three articles which appeared in the publications of the Imperial Academy of Sciences in St. Petersburg.[1]

Owing to the meagreness of the linguistic material, the conclusions of Professor Schiefner could not be very far reaching. Besides, incorrect records and inexact translations of phrases collected by incidental explorers led to wrong conclusions.

However, it can be inferred, even from these articles, that the Yukaghir language stands isolated from the Siberian languages of the so-called Ural-Altaic group; and for that reason it has attracted the attention of linguists.

Since the time of Baron v. Maydell's travels (1868–70), the Yukaghir language has been considered extinct, for the only reason that Baron v. Maydell collected his "Sprachproben" records among the Russianized Yukaghir, on the Anadyr River, from an old woman who still remembered her own language to a certain extent.

But my own investigations have shown that there are still two independent Yukaghir dialects spoken by nearly seven hundred people. But the days of the Yukaghir language are really counted, owing to the gradual dying-out of the people who speak it. Even in the short interval between the two expeditions in which I participated, some Yukaghir families, on the middle course and on the mouth of the Omolon river, who conserved their language became extinct.

The two dialects of the Yukaghir language may be called,—one, the Kolyma; the other, the Tundra dialect. The former

[1] "Über die Sprache der Jukagiren" (*Bull. Hist. Phil.*, XVI, 1859, pp. 241–253; *Mél. asiat.*, III, pp. 595–612). "Beitrage zur Kentniss der jukagirischen Sprache" (*Bull.*, XVI, 1871, pp. 373–399; *Mél. asiat.*, VI, pp. 409–446). "Über Baron v. Maydell's jukagirische Sprachproben" (*Bull.*, XVII, 1871, pp. 86–103; *Mél. asiat.*, VI, pp. 600–626). These articles served the philologist Fr. Müller as a basis for an outline of the Yukaghir language in his work "Grundriss der Sprachwissenschaft," Bd. II, Abth. I, pp. 124–133, Wien, 1882.

was in vogue in the region of the Kolyma River and in the valleys along its tributaries; the latter on the northern tundra, between the lower parts of the Kolyma and Lena Rivers. At the present time the Kolyma dialect is confined to the region along the Yassachna and Korkodon Rivers; and the Tundra dialect to the tundra between the Large Chukchee and the Alaseya Rivers.[1]

Besides, the Chuvantzy language, which is now completely extinct, and which was spoken in the former time to the east of the Kolyma River, also used to be, according to all collected data, a dialect of the Yukaghir language.

The territory where the two former dialects are spoken is indicated upon the accompanying map.

I mastered the Yukaghir language sufficiently to obtain full command of their grammatical forms, and not only to take accurate records of the texts, but also to converse freely in it.

The linguistic material on the Yukaghir dialects collected by me is composed of a hundred and fifty texts, a dictionary containing nine thousand words, in which many words from the texts have not yet been entered, and vast phraseological material for a complete grammatical outline of the two dialects.[2]

The present article is an abridged grammatical sketch of the Yukaghir language. The space at my disposal in the ANNALS OF THE NEW YORK ACADEMY OF SCIENCES does not allow me to introduce into this outline the peculiarities of the Tundra dialect, and the article is thus mainly a brief sketch of the Kolyma dialect. It may be noted here that the phonetical and morpho-

[1] A considerable part of the Yukaghir who used to speak this language has died out; a part, at the mouth of the Omolon River, on the lower course of the Kolyma and on the banks of both the Large Anui and the Dry Anui Rivers has become Russianized; another part, on the tundra between the Indigirka and Yana Rivers, has been assimilated by the Tungus; and still another, on the tundra between the Yana and Lena Rivers, has adopted the Yakut language. (See linguistic map.)

[2] Up to the present time a hundred texts have been published by the Imperial Academy of Sciences at St. Petersburg, under the title, "Materials for the study of the Yukaghir Language and Folk-Lore, collected in the Kolyma District, Part I, St. Petersburg, 1900"; and an article containing a grammatical analysis of one text, in the *Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg*, 1898, Septembre, T. IX, No. 2.

logical peculiarities of the Tundra dialect are rather insignificant, but that it has absorbed a considerable quantity of Tungus stems, which in their further development have been, however, subjected to the laws of the Yukaghir grammar.

PHONOLOGY.

Following is a description of the phonetic elements of the Yukaghir language.

a, e, i, o, u, have their continental sounds (short).

ā, ē, ī, ō, ū, are long vowels.

To avoid the introduction of unnecessary marks, I do not annotate here the obscure vowels separately. It may be said only, that all short vowels are obscure when preceding a spirant or *n*, or following a spirant.

The series of diphthongs is as follows:

ai, ei, oi, ui
ie, iu, uo, eo
au, eu, ou

Their pronunciation is as in German.

Triphthongs are not frequent.

y as in year.

l as in German.

ḷ as in English all.

l' has a spirant added.

r as in French.

m as in English.

n as in English.

ñ is pronounced on the end of the word as *ng* in *being*, and in the middle, as *ng* in the German word *Enge*.

m· palatized *m* (similar to *my*).

n· palatized *n* (similar to *ny*).

b and *p* are pronounced with aspiration, owing to which these consonants are intermediate between *b* and *v*, and *p* and *f*. There is no *v* or *f* in the Yukaghir language. The Tundra dialect, however, has a sound that corresponds to the English *w*. When placed between two vowels, *b* approaches very nearly the sound of *v*.

d, *t* as in English.

ḍ like *dr*.

g like *g* in good.

h as in English.

k as in English.

t‘, *k*‘ have a spirant added. They are placed at the end of a word, if the following word does not commence with a vowel. The same applies to *l*‘.

ťl-t before *l* is pronounced soft, by pressing the tip of the tongue to the front part of the palate. *t* and *l* blend into one sound.

ťn are blended into one nasal sound.

g̣ velar *g*.

ċ like the English *sh*.

č is equal to *ty;* but old men pronounce it so that it sounds more like *ch* in chance, while with women and children it sounds closer to *c* in the German word *Ceder*. This seems to be a trace of the difference between the pronunciation of men and women, just as it exists in the Chukchee language. At the end of the word, *č* is pronounced by women almost like *s*.

j is *dy;* but old men pronounce it more like *j* in the word joy, while women and children pronounce it like *dz*. If it occurs between two vowels, one of which has a long sound, *j* is pronounced like the French *j* in *jour*.

x like *ch* in the German *Bach*.

x‘ like *ch* in the German *ich*, at the end of the word.

The language bears but faint traces of an original harmony of sounds, which is little observed at present. It may be described as follows: *o* in the stem does not tolerate *e* or *a* in the suffix. In the former case, *e* of the suffix is changed into *o;* in the latter, *o* of the stem changes into *a*. For example:

Stem	Suffix		
coro'mo- (man)	*g̣o* (locative) at present	also used *coro'moge*	S. §§ 12 and 32.
coro'mo-	*ḷox*‘ (Def. Nominative) at present	also used *coro'mo-ḷek*‘	
mo'ḷg̣o- (middle)	*dòg̣o* (locative accompanied at present by a possessive element.)	also used *mo'ḷg̣o-dèg̣e*	

mo'do to sit.

madā' to begin the act of sitting, sit down, instead of *mo'doā*, in which case *o* and *ā* combine into one long *ā* (see § 92).

o is a weak vowel, and *g* and *k*, when preceding or following it, change respectively into the corresponding sounds *g* and *x*, as may be seen from the examples. *e* and *a* are strong vowels.

Not all consonants can begin words. The Yukaghir avoid:

1. Clusters of two consonants at the beginning of a word. When pronouncing Russian words beginning with two consonants, the Yukaghir will either drop the first (for example, Russian word *Staru'xa*, "old woman," is pronounced by the Yukaghir *teri'ke*), or they will precede the word by the vowel *i* (for example, the Russian word *sta'riy*, "old," is transformed into *i'čterei*).

2. *r* at the beginning of a word.

3. The occurrence of *b*, *g*, *g*, *j*, and *d*, either at the beginning or the end of a word. In such cases, these letters change into the corresponding surds *p*, *k*, *č*, and *t*.

The first syllable is usually accented in the Yukaghir language. This is an almost invariable rule with dissyllables. There are very few exceptions to this rule; for example, *ajū'* ("word"), *eme'i* ("mother"), *lebie'* ("earth"), and some postpositions, like *yoḷa'* ("after"), *iji'e* ("self"), *alā'* ("near").

Trisyllables are usually accented on the second syllable; but so far I have been unable to establish a rule. This would require a comparative study of a large number of words, which will be made in the elaboration of the dictionary.

Tetrasyllables or polysyllables are mostly accented on the first syllable; but many of them acquire an additional accent, which is usually put on the possessive element of the suffix. I have marked the additional accent by means of a grave accent (`).

Very few words are accented on the third syllable, as, for instance, *pojerxo'* ("day"); but I heard some people pronounce *po'jerxo*.

In adding suffixes to dissyllables, the accent passes to the second syllable: *nu'mo* ("house"), *numo'ge* (c. loc.), but also

nu'moñin (c. dat.). Trisyllables, when accented on the second syllable, usually retain the accent on the same syllable, *coro'mo* ("man"), *coro'mogi* (poss. suf.); but in some cases the accent is transferred to the first syllable, *kude'de* ("to kill"), *ku'dedelle* ("having killed").

The verbal prefixes always take the principal accent: *n·e'-kudède* ("kill each other"), *o't-kudède* ("would kill").

THE PARTS OF SPEECH.

The Noun.

§ 1. *Case-Suffixes.* — Relations between objects are expressed by means of suffixes *only*. I distinguish between case-suffixes and other post-positions (see § 123) also serving to indicate relations between objects, for the reason that the case-suffixes have already lost their distinct sense, and, with the exception of the casus comitativus suffix (see § 123), they cannot constitute a basis for other word formations.

§ 2. Case-suffixes are joined to the following classes of nouns:

§ 3. (1) To nouns proper, that is, to such words as indicate only objects.

§ 4. (2) To verbal nouns. As will be seen below, a considerable part of verbal, that is, predicative, forms, may be used as nouns (see §§ 80, 82, 112, 113), and form any element of the sentence. Only when used as a modifier does the verbal noun remain unchanged (see § 80). In all other cases the case-suffixes are joined to it just as to nouns proper.

§ 5. (3) To personal pronouns, absolute possessive pronouns, and other pronouns used as substantives (see §§ 54, 55, 56, 57). Sometimes case-suffixes are joined to pronouns used as adjectives (see § 56).

§ 6. (4) Most post-positions that are joined to nouns as case-suffixes and substitute prepositions (see § 124).

§ 7. *Possessive Suffixes.* — The possessive suffixes found in the Ural-Altaic as well as in the Eskimo dialects (in which the same possessive suffixes are joined to noun and verbal bases) are in the Yukaghir language altogether absent in verbs and in

nouns for the purpose of indicating the first and second persons. Only to express ownership of a third person is a possessive suffix joined to nouns.

§ 8. The following comparative table illustrates the use of the possessive suffixes in nouns in the Yakut (one of the Ural-Altaic languages) and the Yukaghir languages.

Yakut.			Yukaghir.			
Possessive Pronouns.	Father (Base).	Possessive Suffix.	Possessive Pronouns.[1]	Father (Base).	Possessive Suffix.	
Min	*aha'-*	*m*	*Met*	*eči'e*	—	My father
Bisigi'	*aha-*	*bı't*	*Mit*	*eči'e*	—	Our father
En	*aha'-*	*ñ*	*Tet*	*eči'e*	—	Thy father
esigi'	*aha-*	*hı't*	*Tit*	*eči'e*	—	Your father
Kini'	*aha-*	*ta'*	*Tu'del*	*eči'e-*	*gi*	His father
Kinile'r	*aha-*	*la'r*	*Ti'tel*	*eči'e-*	*pegi*	Their father and their fathers

§ 9. Instead of the possessive suffix =*gi*, another form may be used for the expression of the idea of the relation of ownership between objects. For instance :

1. *Met eči'e numo'-gi*	my father house his, or
2. *Met eči'e-nu'ma*	my father's house.
1. *Met eči'e-d-ā'če-gi*	my father reindeer his, or
2. *Met eči'e-d-āče*	my father's reindeer.

The second form is similar to the Saxon form of the genitive case in the English language (my father's house, my father's reindeer); but it is not the suffix of the genitive case that we meet with here. Only for the sake of euphony is *d* (or *n*) put between the final vowel of the first word and that of the initial in the second word.

§ 10. The possessive suffix is used after the third person of a personal pronoun,

[1] See §§ 54, 55.

tu'del' numo'-gi	he house his (see §8), = his house
ti'tel' numo'-gi	they house their = their house,

but not after a possessive pronoun in the third person,

Tu'de (see § 55) *nu'mo*	his house.
ti'te (see § 55) *nu'mo*	their house.

§ 11. In oblique cases the inflexion expressing the possessive element for the third person is introduced between the base and the case-suffix (see §12).

§ 12. The following table of case-suffixes may be thus compiled:

Case.	Suffixes. Indefinite.	Definite.	With the Possessive Element for the Third Person.
Nominative	Base	*k, x, ḷek, ḷox* or *k', x', ḷek', ḷox'*	*gi* *deñin*
Dative	*ñin*	—	
Locative	*ge* or *go*	—	*dege* or *dogo*
Vialis	*gen* or *gon*	—	*degen* or *dogon*
Ablative	*get'* or *got'*	—	*deget'* or *dogot'*
Accusative	*e, ḷe, ḷo*	*k, x, ḷek, ḷox* or *k', x', ḷek', ḷox'*	*gi* or *geḷe, goḷo, degeḷe*
Instrumental	*ḷe* or *ḷo*	—	*deḷe* or *doḷo*
Comitative	*n·e*	—	*den·e*
Comparative I	*gete, goto*	—	*degete* or *dogoto*
Comparative II	*tite*	—	—
Temporal	*me*	—	—

§ 13. The definite suffixes of the nominative and accusative, though performing the function of the definite article of European languages, do not exactly correspond to them in sense. They are used as a reply to the questions Who or what? Whom or what? if the question relates to the object, and not to the action. The abbreviated form *k* and *x* is used when the noun has a modifier; for instance:

Ki'ntek' keḷul'?	*Who* came?
Coro'mo-ḷok' ke'ḷul'	The or a *man* came.
Omo'če coro'mo-x' ke'ḷul'	The or a *good man* came.

§ 14. It seems to me that the inflection *ḷe* or *ḷo* is nothing but the case of the verb to be (*ḷe*).

Coro'mo-ḷok' ke'ḷul'	The or a man is (who) came.

See §§ 82, 83 with regard to the form *keḷul'*.

§ 15. Suffix *ñin* of the dative indicates :

1. A movement in some direction, and is used in reply to the question Whither? or To whom?

Nu'mo-ñin xonk'	To the house or home go.
Tu'del' unu'-ñin ko'beč	He to the river went.
Met' ke'nme-ñin xo'nje	I to a friend went.

2. An aim, and is used after the question What for?

Met ō'je-ñin kobe'iteye	I for water shall go.

3. Limit.

Tu'del' ḷi'gemuñin[1] *o'moč mo'doi*	He until his old age well lived.

§ 16. *Suffix ge* or *gọ* of the locative is used after the questions Where? At whose house? On whom? On what?

Met' numo'-ge modo'ye	I at home sit.
Met eči'e Iva'n-ge mo'doi	My father at Ivan's lives.

In some cases the locative answers also the question Whither? and expresses motion *into* an object, while the dative mostly indicates motion *toward* an object.

Met' nu'moñin kie'če	I to the house came.
Met' numo'-ge co'uye	I into the house went.

§ 17. The vialis *gen*[2] or *gọn* has apparently been formed from the locative *ge*. This case indicates motion *on the surface*,

[1] *ḷi'gemuñin* = *ḷi'gel* (old age) + *de* (possessive element) + *ñin* (suf. of the dative case). Often *l-de* changes into *mu*.

[2] In the grammatical analysis of the text in my article in the *Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg* (1898, September, T. IX, No. 2, p. 173), I considered this case suffix as an instrumental case ; but my further study of the language in the Jesup Expedition has convinced me that I was wrong in my former definition of this case. To avoid misunderstandings, I consider it necessary to point it out here.

across, or *through* an object, and also ways and means of getting something.

1. *Met ŏ'ji-gen kie'če*	I on water came (on a boat or raft).
2. *Tu'del' ti'bi-d-añi'l-gen yu'odei*	He through the smoke opening (chimney) was looking.
3. *Tu'del' nu'mejigele yu'o-gen moru'cem.*	He his axe under belt put.
4. *Met' te'tul O'nmun-čo'bil-gen ka'udet'*	I you over the Kolyma tundra shall drive.
5. *Met' ču'go-dègen kobe'iteye*	I along his road shall go.
6. *Met ir'kin ăč'ex e'ime-gen min'me*	I one reindeer in exchange took.

§ 18. Suffix *get* or *got* of the ablative indicates motion *from* or *out of* an object, and has apparently been derived from the locative by the addition of *t*.

Tu'del numo'get u'koč	He out of the house went.
Met eči'e-get kie'če	I from the father came.

The ablative is also used for the purpose of expressing the degrees of comparison of adjectives (see § 41).

§ 19. The definite form of the accusative is the same as the definite nominative (see §§ 13, 14). This form remains unchanged after all the three persons. If used as a direct object, it is put between the subject and the transitive verb, in which case the latter is conjugated in the definite conjugation (see § 82).

1. *Met eči'e coro'molok yu'omle*	My father a man saw.
2. *Met eči'e omo'če coro'mox yu'omle*	My father a good man saw.

§ 20. The indefinite form of the accusative, serving as a direct object when the subject is in the first or second person, is equal to the indefinite nominative; that is, the base of the noun. It is only when the subject is in the third person that a special *e*, *le*, or *lo* is joined to the direct object following it.

Met' coro'mo yu'o	I a man saw.
Tet ā'če yu'omik'	Thou a reindeer sawest.
Tu'del' coro'mo-lo yu'om	He a man saw.
Met eči'e ā'če-le yu'om	My father a reindeer saw.

§ 21. It is to be observed that the third person, as a rule, plays a peculiar part in this language. To point out one of these peculiarities: the transitive verb *to give* is expressed by one word (kei, "to give") when the indirect object is in the first or second person, and by an entirely different word (*ta'di*, "to give") if the object is in the third person; for instance:

1. *Met' te'tin e'ye kei*	I thee a bow gave.
2. *Tet' me'tin e'ye ke'imik'*	Thou me a bow gavest.
3. *Eči'e me'tin e'yele ke'im*	Father me a bow gave.
4. *Tu'del' te'tin e'yele keim*	He you a bow gave.

and

1. *Met' tu'din e'ye ta'di*	I him a bow gave.
2. *Tet' tu'din e'ye tadi'mik'*	Thou him a bow gavest.
3. *Tudel' tu'din e'yele ta'dim*	He him a bow gave.
4. *Mit ani'je met eči'eñin e'yele ta'dim*	Our chief to my father a bow gave.

§ 22. In the same manner, it is only to express ownership of a third person that the object has a possessive element, which is expressed by *gi* in the nominative; *gi*, *ge*, or *dege* in the accusative; and *de* in all other oblique cases. The possessive element is placed between the base and the case-suffix (see § 12).

nu'mo-ñin	To the house;	*nu'mo-deñin*	To his house.
numo'-ge	In the house;	*nu'mo-dege*	In his house.

§ 23. It is very likely that *de* is an abbreviation of the possessive pronoun *tu'de* (see § 55) "his."

§ 24. The element *de* indicates that an object in the oblique case belongs either to the subject if it is in the third person, to the direct object if it is in the third person, or to some third person; for instance:

1. *Met eči'e nu'mo-dè-get u'koč*	My father of his house came out.
2. *Tet' mit ani'je nu'mo-dège me'tul' nugte'mik'*	Thou our chief in his house me wilt find, *i. e.*, thou wilt find me in our chief's house.

3. *Tu'del' me'tkele n'em, met' nu'modege co'uye* — He called me, I into his house went.

§ 25. The inflection *ge* of the accusative is used in a word constituting a direct object of the subject in the third person, if the direct object belongs to the first or second person, or to the subject proper.

Examples without the element *ge:*

1. *Met' tet' mo'go min·* — I thy cap took.
2. *Tet' met' mo'go mi'n·mik'* — Thou my cap tookest.
3. *Tu'del' mo'go-lo mi'jum* — He a cap took.

Examples with the element *ge:*

1. *Tu'del' met' mo'go-gele mi'jum* — He took my cap.
2. *Eči'e tet' mo'go-gele mi'jum* — Father took thy cap.
3. *Eči'e tu'de mo'go-gele mi'jum* — Father his cap took.

§ 26. The inflection *dege,* or *deu* in its abbreviated form, is introduced to indicate that the direct object belongs not to the subject, but to some third person.

Met eči'e yo'ndodège, met čača mo'godegele (or *mo'godeùle*) *mi'jum* — My father when he slept (in his sleep) my elder brother his (*i. e.*, father's) cap took.

§ 27. The suffix of the instrumental case, *le,* signifies an instrument or a means. Though the indefinite accusative has the same suffix, *le,* the two seem to be of a different origin. The instrumental suffix *le* is used indifferently, no matter what person the subject may be.

1. *Met' lī'pe-le xa'rte* — I with a spade dig.
2. *Tet ā'če-le*[1] *kie'ček'* — Thou camest on reindeer.

§ 28. The suffix of the comitative case *n·e,* is used in place of the preposition *with.*

Met eči'e-n·e kie'če — I with father came.
Tu'del eči'e-den·e mo'doi — He with his father lives.

[1] *Ā'če-le* is, properly speaking, in the singular number; but in such cases the singular is frequently used instead of the plural.

§ 29. The suffix of the comparative I case *gete*, signifies "as compared" with; for instance:

Met eči'e-gete tu'del' čo'moi — With my father compared he is big (*i. e.*, bigger).

§ 30. The suffix of the Comparative II Case, *ti'te*, means *like;* for example:

Tu'del' met eči'e-ti'te e'rče coro'mox' — He like my father is a poor man.

§ 31. Temporalis *me* or *mo* changes a noun into an adverb of time:

Pojerxo'	day;	*pojerxo'-mo*	in the daytime.
Ogo'ye	to-morrow;	*o'goyel-me*	in the morning.
Yu'ole	evening;	*yu'ole-me*	in the evening.

§ 32. Complete Table of Declension of a Noun.

Case.	Indefinite Suffixes.	Definite Suffixes.	With a Possessive Element.
Nominative	*Eme'i-mother*	*Emeik'; Emeilek'*	*Eme'igi*
Dative	*Eme'iñin*	—	*Eme'ideñin*
Locative	*Eme'ige*	—	*Eme'idege*
Vialis	*Eme'igen*	—	*Eme'idegen*
Ablative	*Eme'iget'*	—	*Eme'ideget'*
Accusative	*Eme'ile*	*Emeik'; Emeilek'*	*Eme'igi; Eme'igele; Eme'ideule (=Eme'idegele)*
Instrumental	*Eme'ile*	—	*Eme'idele*
Comitative	*Eme'in·e*	—	*Eme'iden·e*
Comparative I	*Eme'igete*	—	*Eme'idegete*
Comparative II	*Eme'i-ti'te*	—	—
Temporalis	—	—	—

§ 33. *Plural Number.*—The plural is formed by the addition of *pe* or *pul'*. It is very difficult to define by a general rule when one of these forms should be used. Most nouns receive the addition, now of one, now of the other, of these two forms. For instance, *coro'mo* (man) may be *coro'mo-pe* and *coro'mo-pul'* in the plural. Generally *pe* is preferred after a consonant and

a long vowel, — *polu't-pe* (old men), — and *pul'* after a short vowel, — *e'mje-pul'* (younger brothers or sisters, or both).

§ 34. The plain suffix *pe*, or the double one *pepul*, is joined to the following words in plural :

	Singular.	Plural.
koi	boy, fellow, young man	*k'oipe* and *k'oipepul'*
pai	young woman	*pa'ipe* and *pa'ipepul'*
ke'nme	friend	*kenne'pe* [1] and *kenne'pepul'*
u'o	child	*uo'rpe* [2] and *uo'rpepul'*

K'oipe and *pa'ipe* are used as if they were in the singular. They say, for instance, *i'rkin pai* and *i'rkin pa'ipe*, one young woman.

§ 35. It is quite likely that *pe* is a suffix of the now extinct dual number. For example, *Ečí'e-pe* (fathers) means either father and mother together (*i. e.*, parents) or the father and his elder brother ; [3] while *Ečí'e-pul'* means many fathers. I have not found any more traces to confirm my supposition. With regard to the above-mentioned double suffixes for the expression of plurality, I have noticed that, when these words are preceded by a numeral which does not exceed 5, one suffix is joined to them, and, if it exceeds 5, a double suffix is added ; for instance :

yan pa'i-pe	three young women, and
ma'lgiyan pa'i-pepul'	six young women.

§ 36. The element expressing plurality is placed in the nominative and all oblique cases, between the base and the other suffixes. *A'če-pul-ñin*, to the reindeer (plural), and *ăče-pul-de-ñin*, to his reindeer (plural). We have thus the following order: Base + element of plurality + possessive element + case-suffix.

§ 37. Very often the element *pe*, when preceding another suffix, drops the *e*; for instance, *ă'če-p-ki* (his reindeer), instead of *ă'če-pe-gi*, *g* changing into *k* when preceded by *p*.

[1] *m* followed by *p* changes into *n*.

[2] *r* is put between the diphthong and *p* for euphony.

[3] The elder brother of the father is called *čomō'čie*, that is, the big father.

§ 38. The Yukaghir language has no grammatical distinction of gender. With reference to people, if there are no special names to indicate sex — as, for instance, *eči'e* (father) and *eme'i* (mother), *po'lut'* (old man, husband), *teri'ke* (old woman, wife) — the words *koi*, *koyo'je*, or *a'dil'* (fellow, man), or *pai*, *payo'je*, or *ma'rxil'* (woman, girl) are prefixed for that purpose.

koyo'je-d-e'mje	younger brother	(*emje* = younger
pay'oje-d-e'mje	younger sister	brother, or sister)
A'duo (instead of *A'dil-u'o*)	son	(*u'o* = child)
Ma'rxi-d-uo	daughter	

To indicate the sex of animals, nouns are preceded by *o'nčeñoje*[1] for the male, and *mo'iñoje*[2] for the female.

O'nčeñoje-caxa'le male fox ; *mo'iñoje-caxa'le* female fox

The male of the wild reindeer is called simply *o'nče*, or *o'nčie*, and that of the elk, *pie'je*. The female of the wild reindeer is *i'rogoje*, and that of the elk, *ū'oye*.

§ 39. The suffix for the augmentative form of nouns is *te'ge*, and for the diminutive, *di'e*. *Nu'mo-tège* (large house), *nu'mo-dìe* (small house).

The Adjective.

§ 40. The adjective has no special form. Instead of it, participles and other verbal forms (see §§ 80, 84) are used. All forms taking the place of adjectives are used as modifiers, put before the modified word, and do not undergo any changes.

Omo'če coro'mox	good man.
či'tneye-d- ige'yé[3]	long thong.

§ 41. Degrees of comparison.

1. The comparative degree is formed by means of the ablative of one of the nouns compared and a verbal form in the third person ; for instance :

[1] Generator or provider.

[2] Keeper.

[3] *d* is inserted for euphony.

Met eči'e-get' tu'del' li'gei, my father from he is old; that is, he is older than my father.

2. The superlative is formed by means of the ablative of one of the nouns compared preceded by the pronoun *ču'mut'* (all).

Ču'mut odu'peget'[1] *tu'del' li'gei,* all the Yukaghir from he is old; that is the oldest.

Numerals.

§ 42. The following are the principal cardinal numbers:

	Independent.	Used as Modifiers.		
1.	*Irki'ei*	*I'rkin*	*coro'mox*	(one man).
2.	*A'taxloi*	*A'taxun*	"	two men.
3.	*Ya'loi*	*Yan*	"	three "
4.	*Ya'loxloi* (three and one)	*Ye'lokun*	"	four "
5.	*I'n·gan·boi*	*I'n·gan·boje*	"	five "
6.	*Ma'lgiyaloi*[2] (two times three)	*Ma'lgiyan*	"	six "
7.	*Purki'oi* (one above, one more)	*Purki'yin*	"	seven "
8.	*Ma'lgiyèloxloi*[2] (two times four)	*Ma'lgiyelokun*	"	eight "
9.	*Kuni'rkilejeoi* (ten, one missing)	*Kuni'rkilejeoje*	"	nine "
10.	*Ku'nel'*	*Kuni'yin*	"	ten "

§ 43. Judging from the above list of numerals, one might draw the conclusion that the Yukaghir system of numeration is not quinary, as it is with the Chukchee, Eskimo, and most of the Indians, but tertiary. But it should be pointed out on the other hand, that *in·'gan·boi* (five), as it seems to me, contains the word *xa'n·bo* (palm, wrist, *i. e.*, five fingers) since *x* preceded by *n·* change into its corresponding consonant *g*; *in*

[1] Instead of *odu'lpeget'*, from *odul'*, Yukaghir.

[2] *Ma'lgi* or *Malgil'* means joint. *N·e'malgil'* (all the joints together) means a year. *Ma'lgiyaloi, malgiyeloxloi,* mean joint-three, joint-four, *i. e.*, each one contains three or four.

equals *n·i* or *n·e* (together). And if this be so, the Yukaghir system of numeration has two bases. Unfortunately, I have been unable so far to discover the meaning of the word *ku'nel'* (10).

§ 44. All the rest of the tens are composed by multiplying 10 (*ku'nel'*) by the number of tens which precede the ten. Thus, twenty = *a'taxun-ku'nel'* (two tens), sixty = *ma'lgiyan-ku'nel'* (six tens), etc.

Units are put after the tens with the addition of the post-position *budi'* (on top, over and above); for instance:

11. *Kuni'rkibudi'* = *ku'nel-irkin-budi* (ten, one over).
34. *Ya'nkunelyélokunbudi* (three tens, four over).
76. *Purki'yinku'nelmalgiya'nbudi'* (seven tens and six on top).

§ 45. The independent cardinals are verbal forms in the third person, positive form, singular, present-preterite tense, indefinite conjugation of intransitive verbs (see § 75). They may be inflected like verbs, but not like nouns. For instance, to the question, "How many?" you reply, "*Yaloi* ("three"); but to the question, "How many men?" the answer is, "*Yan coro'mox'*" ("three men").

The plural[1] number, present-preterite tense, will be:

Mit ya'loyeili we three are,	or we three have been.
tit ya'loyemet' you three are,	or you three have been.
ti'tel ya'loñi they three are (three of them),	or they three have been.

The future tense, plural:

Mit ya'loteili	we three shall be.
tit ya'loteyemet'	you three will be.
ti'tel ya'loñitei	they three will be.

§ 46. Cardinal modifiers used as adjectives remain unchanged, only the words modified by them undergo case-inflections.

§ 47. There are no Yukaghir words for numbers above a hundred. They used to say *ku'nel'-ku'nel'* (ten tens) for hundred:

[1] It is plain that there can be no singular.

but now they say *ičto'x* (the Russian *sto*). The Russian word for thousand (*ti'syača*) has also been adopted by them; but they pronounce it *ti'čeče*.

§ 48. Ordinal Numbers.

	Independent.	As Modifiers or Attributive.		
The 1st	*a'ñnume*[1]	*a'ñnume-le*	coro'mox'	(man)
" 2d	*a'taxlecki*	*a'taxlecte*	"	"
" 3d	*ya'lmecki*	*ya'lmecte*	"	"
" 4th	*ya'laxlecki*	*ya'laxlecte*	"	"
" 5th	*i'n·ganbecki*	*i'n·gan·becte*	"	"
" 6th	*ma'lgiyàlmecki*	*ma'lgiyàlmecte*	"	"
" 7th	*purki'yecki*	*purki'yecte*	"	"
" 8th	*ma'lgiyàlexlecki*	*ma'lgiyàlexlecte*	"	"
" 9th	*kuni'rkilejeocki*	*kuni'rkilejeocte*	"	"
" 10th	*kune'lecki*	*kune'lecte*	"	"
" 11th	*kuni'rkibudìcki*	*kuni'rkibudìcte*	"	"
" 20th	*a'taxun-kunèlecki*	*a'taxunkunèlecte*	"	"
" 22d	*ku'nel-àtaxulbudìeki*	*ku'nelàtaxulbudìcte*	"	"
etc.		etc.		

§ 49. Ordinal numbers are derived from the cardinals partly by means of verbal suffixes. *C* is the suffix which changes a transitive verb into a causative (see § 97); *ki* (instead of *gi*, since *g* preceded by *c* changes into *k*) is the possessive suffix of the nominative case (see § 9); and *te* (in place of *de*, *d* changing into *t* after *c*) is the suffix of the conditional mode (see § 87).

§ 50. Distributive numerals:

a'taxlonut' by two   *i'n·gan·bonut'* by five, etc.

Nu is the suffix of the iterative form of the verb (see § 103,) *t* is the suffix of the verbal adverb (see § 115).

§ 51. Iterative numerals:

Irki'je once   *ataxli'je* twice   *yàli'je* thrice, etc.

§ 52. Fractions. One-half = *Eimunde*. The rest are com-

[1] *aññume* means "at first, in the beginning"; *aññumele*, "initial, first." This is the only ordinal number that is not formed from a cardinal.

posed of the attributive ordinals with the addition of the possessive suffix *gi;* for instance:

Yalmectegi = ⅓.

§ 53. Collective numerals:

ataxlot' two together *yalot'* three together *yaloxlot'* four together, etc.

Pronouns.

§ 54. Personal pronouns: *met'*, I; *tet'*, thou; *tu'del'*, he; *mit'*, we; *tit'*, you; *ti'tel'*, they. The gender is not indicated in the third person. The compound personal pronouns are formed by annexing the post-position *eji'e* (self) to the personal pronouns: *Met-eji'e* (myself), *tet-eji'e tud-eji'e*, etc.

§ 55. Possessive modifying pronouns for the first and second persons are the same as the personal, for instance, *Met eči'e* (my father); while the third is *tu'de* in the singular and *ti'te* in the plural. The possessive modifying pronouns do not change. The following are the absolute possessive pronouns:

me'ł̃le mine	*te'ł̃le* thine	*Tu'dele* his, hers
mi'ł̃le ours	*ti'ł̃le* yours	*ti'tele* theirs

Absolute possessive pronouns assume case-suffixes.

§ 56. Demonstrative pronouns: *Tiñ*, this; and *tañ*, that. These two pronouns are used only as modifiers before nouns, and remain unchanged in most cases. After verbal nouns ending in *l'* (see § 84) *tañ* is joined as a post-position, and the case-suffixes are joined to it, while the verbal noun remains unchanged. For instance, *yu'oḷ-tañ*, that one who saw; *ḷi'geḷ-tañ*, that old one. *Tañ* rather corresponds here to the relative pronouns which, who.

Tu'bon (this) and *Ta'bun* (that) are mostly independent pronouns, like the German *derjenige*, and assume case-affixes. But in some cases they are used as modifiers, and are declined nevertheless (see the text).

§ 57. Interrogative pronouns:

kin who, *ḷe'me* what, *xa'mun* how many (much) and *nu'mun* which.

Kin and *ḷe'me* are declined.

§ 58. Indefinite pronouns:

yen, ye'nḷek', ye'nbon	another	*ču'mu, ču'mut'*	all
i'ḷḷe	some, certain	*o'nmun*	every

Of these pronouns, *ye'nbon* and *i'ḷḷe* (if not used as modifiers) are declined.

o'nmun is used as a post-position; *coro'mo-onmun*, man every.

§ 59. There are no relative pronouns. Verbal nouns ending in *bon* (see § 112) are used instead of them (see also § 56).

§ 60. The table on following page illustrates the declension of personal and other pronouns.

§ 61. With the exception of a few phonetic peculiarities, the case-suffixes of pronouns are the same as those of nouns.

Me'tin is used instead of *me'tñin*, since *ñ* cannot follow *t*.

Me'ťn·e, in place of *me'tn·e*, since *t* and *n* blend into one nasal sound, *ťn*.

Tubo'dek', instead of *Tubo'nḷek'*, etc.

Special attention should be called to the accusative indefinite of the personal pronouns, first and second persons, singular as well as plural number. The accusative indefinite of these pronouns has a special suffix for the direct object following a subject in the first and second person. In nouns, this form is identical with the nominative indefinite (see § 20). For example:

Met' te'tul' kude'det'	I thee shall kill.
Tet' me'tul' ka'udetmik'?	thou me wilt conduct?

but

Tu'del' me'tkeḷe ka'udem	he me conducted.

§ 62. The possessive absolute pronouns, *Me'ťle*, etc., assume the suffix of plurality, *pul'*, which in oblique cases is put between the case-suffix and the base:

Mi'ťlepul'	ours	*Mi'tle-pul-ñin*	to ours.

§ 63. *Tu'bon, Ta'bun, Tañ, kin, ḷe'me, ye'nbon, n'ilgi, xo'dimei'*, assume the suffix *pe* or *pul'* for the plural:

TABLE OF DECLENSION OF PRONOUNS (to § 60).

Cases	I	thou	he	this	who	what	mine
Nom. indef.	*met'*[1]	*tet'*[1]	*tu'del'*[1]	*tu'bon*[1]	*kin*	*ḷe'me*[1]	*me'tle*[1]
" def.	*me'tek'*	*te'tek'*	*tu'del'*	*tubo'dek'*	*ki'ntek'*	*ḷe'mdik'*	—
Dative	*me'tin*	*te'tin*	*tu'din*	*tubo'ñin*	*ki'ñin*	*ḷe'meñin*	*me'tleñin*
Locative	*me'tke*	*te'tke*	*tu'dege*	*tubo'nge*	*ki'nge*	*ḷeme'ge*	*me'tlege*
Vialis	*me'tken*	*te'tken*	*tu'degen*	*tubo'ngen*	*ki'ngen*	*ḷeme'gen*	*me'tlegen*
Ablative	*me'tket'*	*te'tket'*	*tu'deget'*	*tubo'nget'*	*ki'nget'*	*ḷeme'get'*	*me'tleget'*
Accusative	*me'tul'* or	*te'tul'* or	*tu'del'* or	*tu'bon* or	*kin* or	*ḷe'me*	*me'tle* or
indefinite	*me'tkeḷe*	*te'tkeḷe*	*tu'degeḷe*	*tubo'ngeḷe*	*ki'ngeḷe*		*me'tlegeḷe*
						ḷe'megeḷe	
Accus. def.	*me'tek'*	*te'tek'*	*tu'del'*	*tubo'dek'*	*ki'ntek'*	*ḷe'mdik'*	—
Instrumental	—	—	—	*tubo'nḷe*	—	*ḷe'meḷe*	—
Comitative	*me'tn·e*	*te'tn·e*	*tude'n·e*	*tubo'nn·e*	*ki'nn·e*	*ḷe'men·e*	*me'tlen·e*
Compar. I	*me'tkete*	*Te'tkete*	*tu'degete*	*tubo'ngete*	*ki'ngete*	*ḷe'megete*	—
" II	*me't-tite*	*te't-tite*	*tu'del-ti'te*	*tu'bon-ti'te*	*ki'n-tite*	*ḷe'me-ti'te*	—

[1] *Mit'* is declined like *Met'*; *Tit'*, like *Tet'*; *Titel'*, like *Tudel'*; *Ta'bun* and *Yenbon* like *Tubon*; *Te'tle* (thine), *Tude'le* (his), *Mi'tle* (ours), *ti'tle* (yours), and *Tite'le* (theirs), like *Me'tle*. *Tiñ*, *tañ*, *ni'lgi*, *xo'dimei*, are declined like *Tu'bon*.

Tabu'n-pe ke'lñi	Those came.
Ki'n-pe-get' kelmet'?	From whom (you) came?
Ke'lul-tàñ-pe tī le'ñi	Arrived those here are, or those that arrived are here.

Tañ is one of the forms that are used as substitutes for relative pronouns (see § 56).

The Verb.

§ 64. While almost all the noun-bases are derivatives of verbal forms, the bases of verbs are in most cases disyllabic or monosyllabic roots, frequently consisting of one vowel. For instance, *ā* expresses the conception of "doing"; *ū*, that of being born; *o*, to draw, to get from the bottom. But nouns can, in their turn, become verbs again by means of the suffixes *te* (for transitive verbs) and *de* (for intransitive verbs). For example: *ō'ji* (from *o*, to drawn, and *ō'je*, to drink), water; *ōji'te*, to supply some one with water; *nu'mo*, a house; *numo'-de*, to be with a house.

§ 65. While the nominative indefinite always constitutes the base of a noun, that of verbs does not always coincide with one and the same form. The first person, singular, present-preterite, indefinite conjugation, is the base of transitive verbs, while that of the intransitive coincides with the third person, singular, of the negative form, present-preterite, indefinite conjugation (see § 75, table of conjugations).

§ 66. Verbs have only two tenses, the present-preterite or perfect and the future or imperfect. The action may be either completed or yet to be completed. The performance of an action consists of a continual succession of moments, every one of which appears in a given moment with reference to the acting person, either as past or future.[1]

Met' kude'de	I have killed, and I kill.
Met' kude'det'	I shall kill.

[1] The present-preterite is also to be found in the Gilyak language (L. J. Sternberg, Material for the Study of the Gilyak Language and Folk-Lore [Bull. of the Imp. Academy of Sciences, Vol. VIII, No. 4, p. 422, November 1900, St. Petersburg]).

Mode.

§ 67. The following modes may be enumerated: imperative indicative, optative, conjunctive, conditional, supine, perfective, potential, evidential, inchoative.

§ 68. The Yukaghir language has no infinitive mode. It is replaced by the supine. But when naming an action for illustration, I translate the English infinitive by giving the base of the Yukaghir verb (see § 65).

§ 69. Before proceeding to explain the formation of voices and other derivative forms, which are so numerous in the Yukaghir language, and which are called "aspects" in the Slav languages, or as the well-known Russian philologist, Nekrassoff, calls them "degrees of action," I shall point out how the verbal bases are being inflected according to modes, since all verb bases, no matter of what voice or degree of action, are inflected in the same manner with reference to mode.

§ 70. Every verb has two forms of conjugation, the definite and the indefinite.

§ 71. The indefinite has three forms in the indicative mode, a positive, a negative, and an interrogative.

§ 72. The imperative mode has two forms, a positive and a negative.

§ 73. The forms of the imperative mode are the same for transitive and for intransitive verbs.

§ 74. The indicative mode has different forms for transitive and for intransitive verbs.

§ 75. The following tables illustrate the indefinite conjunction of transitive and intransitive verbs.

INDEFINITE CONJUGATION OF VERBS.

				Transitive.			Intransitive.		
			Base.	*lī* (to have).	*min·* (to take).	*kude'de* (to kill).	*le* (to be).	*xon* (to go somewhere).	*u'i* (to work).
Imperative Mode, Present Tense.									
Positive Form.	Singular.	1.	*met‘*						
		2.	*tet‘*	*lī-k‘*	*min·-k‘*	*kude'de-k‘*	*lek‘*	*xon-k‘*	*ui-k‘*
		3.	*tudel‘*	*lī'gen*	*mi'n·-gen*	*kude'de-gen*	*le'-gen*	*xo'n-gen*	*u'i-gen*
	Plural.	1.	*mit‘*						
		2.	*tit‘*	*lī'-ñik‘*	*mi'n·-ñik‘*	*kude'de-ñik‘*	*le'-ñik‘*	*xo'n-ñik‘*	*u'i-ñik‘*
		3.	*titel‘*	*lī'-ñigen*	*mi'n·-ñigen*	*kude'de-ñigen*	*le'-ñigen*	*xo'n-ñigen*	*u'i-ñigen*
Negative Form.	Singular.	1.							
		2.		*el-lī'-ḷek‘*	*el-mi'n·-ḷek‘*	*el kude'de-ḷek‘*	*el le'-ḷek‘*	*el xo'n-ḷek‘*	*el u'i-ḷek‘*
		3.		*el-lī'-gen*	*el-mi'n-gen*	*el kude'de-gen*	*el le'-gen*	*el xo'n'gen*	*el u'-i-gen*
	Plural.	1.							
		2.		*el-lī'-ñiḷek‘*	*el-mi'n·-ñiḷek‘*	*el kude'de-ñiḷek‘*	*el le'-ñiḷek‘*	*el xo'n-ñiḷek‘*	*el u'i-ñiḷek‘*
		3.		*el-lī'-ñigen*	*el-min·-ñigen*	*el kudede-ñigen*	*el le-ñigen*	*el xon-ñigen*	*el u'i-ñigen*
Future Tense.									
Positive Form.	Singular.	1.							
		2.		*lī'-gek‘*	*mi'n·-gek‘*	*kude'de-gek‘*	*le'-gek‘*	*xo'n-gek‘*	*u'i-gek‘*
		3.							
	Plural.	1.		*lī'-ge*	*mi'n·-ge*	*kude'de-ge*	*le'-ge*	*xo'n-ge*	*u'i-ge*
		2.							
		3.							

Indicative Mode.—Present-Preterite.

Form	Number	Transitive.			Intransitive.		
Positive Form.	Singular.	1. *lī*	*min·*	*kude'de*	*le'-ye*	*xo'n-je*	*u'i-če*
		2. *lī'-mik'*	*mi'n·-mik'*	*kude'de-mik'*	*le'-yek'*	*xo'n-jek'*	*u'i-ček'*
		3. *lī-m*	*mi'-jum*	*kude'de-m*	*le-i*	*xo'n-ni*	*u'i-č*
	Plural.	1. *lī'-i*	*mi'j-i*	*kude'de-i*	*le'-ili*	*xon-je'ili*	*u'i-čeili*
		2. *lī'-met'*	*mi'n·-met'*	*kude'de-met'*	*le'-yemet'*	*xo'n-jemet'*	*u'i-čemet'*
		3. *lī'-ñam*	*mi'n·-ñam*	*kude'de-ñam*	*le'-ñi*	*xo'n-ñi*	*u'i-ñi*
Negative Form.	Singular.	1. *el-lī'-ye*	*el-mi'n·-je*	*el-kude'de-ye*	*o'i-le-ye*	*el-xo'n-je*	*el-u'i-če*
		2. *el-lī'-yek'*	*el-mi'n·-jek'*	*el-kude'de-yek'*	*o'i-le-yek'*	*el-xo'n-jek'*	*el-u'i-ček'*
		3. *el-lī'-i*	*el-mi'n·-i*	*el-kude'de-i*	*o'i-le*	*e'l-xon*	*e'l-ui*
	Plural.	1. *el-lī'-yeili*	*el-mi'n·-ieili*	*el-kude'de-yeili*	*o'i-le-ili*	*el-xon-je'ili*	*el-u'i-čeili*
		2. *el-lī'-yemet'*	*el-mi'n·-jemet'*	*el-kude'de-yemet'*	*o'i-le-yemet'*	*el-xo'n-jemet'*	*el-u'i-cemet'*
		3. *el-lī'-ñi*	*el-mi'n·-ñi*	*el-kude'de-ñi*	*o'i-le-ñi*	*el-xo'n-ñi*	*el-u'i-ñi*
Interrog. Form.	Singular.	1. *lī-m*	*mi'j-um*	*kude'de-m*	*le-m*	*xo'n-om*	*u'-im*
		2. *lī'-mik'*	*mi'n·-mik'*	*kude'de-mik'*	*lek'* or *le-yek'*	*xonk'* or *xo'njek'*	*ui-k'* or *u'i-ček'*
		3. *lī-m*	*mi'j-um*	*kude'de-m*	*le*	*xon*	*ui*
	Plural.	1. *lī'-ḷuok,*	*mi'ji-ḷuok'*	*kude'de-ḷuok'*	*le-ḷuok'*	*xo'n-uok'* or *xo'nu-ḷuok'*	*u'i-ḷuok'*
		2. *lī'-met'*	*mi'n·-met'*	*kude'de-met'*	*le-yemet'*	*xo'n-jemet'*	*u'i-čemet'*
		3. *lī'-ñam*	*mi'n·-ñam*	*kude'de-ñam*	*le-ñi*	*xo'n-ñi*	*u'i-ñi*

Indicative Mode.—Future.

			Transitive.			Intransitive.		
Positive Form.	Singular.	1.	*lī-t'*	*mi'j-ut'*	*kude'de-t'*	*le'-če*	*xo'n-teye*	*u'i-teye*
		2.	*lī'-temik'*	*mi'n·-temik'*	*kude'de-tmik'*	*le'-ček'*	*xo'n-teyek'*	*u'i-teyek'*
		3.	*lī'-tem*	*mi'n·-tem*	*kude'de-tem*	*le'-ti*	*xo'n-tei*	*u'i-tei*
	Plural.	1.	*lī'-tei*	*mi'n·-tei*	*kude'de-tei*	*le-če'ili*	*xon-te'ili*	*ui-te'ili*
		2.	*lī'-temet'*	*mi'n·-temet'*	*kude'de-tmet'*	*le'-čemet'*	*xo'n-teyemet'*	*u'i-teyemet'*
		3.	*lī'-ñītem*	*mi'n·-ñitem*	*kude'de-ñitem*	*le'-ñitei*	*xo'n-ñitei*	*u'i-ñitei*
Negative Form.	Singular.	1.	*el-lī'-teye*	*el-mi'n·-teye*	*el-kude'de-teye* or *el-kude'de-ce*	*el-le-če* or *oi'leče*	*el-xo'n-teye*	*el-u'i-teye*
		2.	*el-lī'-teyek'*	*el-mi'n-teyek'*	*el-kude'de-teyek'* or *el-kude'de-ček'*	*el-le-ček'* or *oi'leček'*	*el-xo'n-teyek'*	*el-u'i-teyek'*
		3.	*el-lī'-tei*	*el-mi'n·-tei*	*el-kude'de-ti* or *el-kude'detei*	*el-le-t'*	*el-xo'n-ut'*	*el-u'i-t'*
	Plural.	1.	*el-lī'-teili*	*el-mi'n·-teili*	*el-kude'de-teili* or *el-kude'de-čeili*	*el-le-če'ili*	*el-xon-te'ili*	*el-ui-te'ili*
		2.	*el-lī'-teyemet'*	*el-mi'n·-teyemet'*	*el-kude'de-teyemet'* or *el-kude'de-čemet'*	*el-le'-čemet'*	*el-xo'n-teyemet'*	*el-u'i-teyemet'*
		3.	*el-lī'-ñitei*	*el-mi'n·-ñitei*	*el kude'-ñitei*	*e'l-le'-ñit'*	*el-xo'n-ñit'*	*el-u'i-ñit'*
Interrogative Form.	Singular.	1.	*lī'-tem*	*mi'n·-tem*	*kude'de-tem*	*le'tum*	*xo'n-tem*	*u'i-tem*
		2.	*lī-te'mik'*	*mi'n·-te'mik'*	*kude'de-te'mik'*	*le'-ček'*	*xo'n-teyek'*	*u'i-teyek'*
		3.	*lī'-tem*	*mi'n·-tem*	*kude'de-tem*	*le'-t'*	*xo'n-ut'*	*u'i-t'*
	Plural.	1.	*lī-tu'ok'*	*min·-tu'ok'*	*kude'de-tu'ok'*	*le-tu'ok'*	*xon-tu'ok'*	*ui-tu'ok'*
		2.	*lī'-temet'*	*mi'n·-temet'*	*kude'de-temet'*	*le'-čemet'* or *le'-tmet'*	*xo'n-teyemet'* or *xon-temet'*	*u'i-teyemet'* or *u'i-temet'*
		3.	*lī'-ñitem*	*mi'n·-ñitem*	*kude'de-ñitem*	*le'-ñit'*	*xon-ñit'*	*u'i-ñit'*

§ 76. The following remarks should be added to the above tables.

§ 77. The Yukaghir language has the transitive verb *lī* (to have), which is absent in the Ural-Altaic languages.

§ 78. Intransitive verbs whose base ends with a short vowel assume the suffixes *je, jek‘*, etc., in the present-preterite, and *če, ček‘*, etc., in the future tense; with a long vowel or a diphthong they assume the suffixes *če, ček‘*, etc., in the present-preterite, and *teye, teyek‘*, etc., in the future; while those ending in a consonant have the suffixes *je, jek‘*, etc., or *če, ček‘*, etc., for the former, and *teye, teyek‘*, etc., for the latter tense.

§ 79. The negative conjugation of transitive verbs corresponds to the positive conjugation (with the exception of the negative prefix *el*) of intransitive verbs.

§ 80. All forms of the indefinite conjugation are actual predicate forms. It is only the first person, singular number, present preterite, of intransitive verbs that may be used as a modifier when put before a noun. It thus takes the place of adjective forms, which are absent in the Yukaghir language (see § 40). For instance:

1. *Met‘ le'ye*	I am, or I live.
2. *Le'ye čoro'mox‘*	Living, existing man.
1. *Met ebi'beye*	I am black.
2. *Ebi'beye xar*	A black skin.

§ 81. The interrogative form is used only when it does not refer to the verb itself. For instance:

Mit e'ye ā'tei?	Will we *make* a bow?

ātei is the positive form, but in the expressions,

Mit‘ xani'n e'ye atu'ok‘?	*When* will we make a bow?
Mit‘ xa'mlol e'ye atu'ok‘?	*How many* bows will we make!

the verb is used in the interrogative form.

§ 82. Definite Conjugation.

Present-Preterite.

		Transitive.	Intransitive.
Singular.	1.	*kude'de-me*	*lo'do-l‘*
	2.	" *-me*	" *-l‘*
	3.	" *-meḷe* or *kude'de-mḷe*	" *-l‘*
Plural.	1.	" *-l‘*	" *-l‘*
	2.	" *-met‘*	" *-l‘*
	3.	" *-ñimeḷe*	" *-ñil‘*

Future.

		Transitive.	Intransitive.
Singular.	1.	*kude'de-tme*	*lodo-tel‘*
	2.	" *-tme*	" *-tel‘*
	3.	" *-tmeḷe*	" *-tel‘*
Plural.	1.	" *-tul‘*	" *-tel‘*
	2.	" *-temet‘*	" *-tel‘*
	3.	" *-ñitemḷe*	" *-ñitel‘*

§ 83. In the definite conjugation, the predicate is used when the subject is in the definite nominative case, or the direct object in the definite accusative. For instance:

1. *Met‘ lodo'-ye*	and 2. *Me'tek‘ lo'dol‘*	I played.
1. *Met‘ lodo'-teye*	and 2. *Me'tek‘ lodo'tel‘*	I shall play.

or

1. *Tet‘ kude'demik‘*	and 2. *Te'tek‘ kude'de-me*	Thou hast killed.
1. *Tet‘ kude'detmik‘*	and 2. *Te'tek‘ kude'det-me*	Thou wilt kill.
3. *Met ā'če kude'de*	and 4. *Met ā'čeḷek‘ kude'-deme*	I killed a reindeer.

The examples (1) may be used to answer the question, Who *did*, or *will do*, a certain thing? while (2) are used in reply to the question, *Who* did or will do a certain thing? (3) answers the question, What I *did?* and (4) answers the question, *What* I killed?

§ 84. When the form of the first person, singular number, present-preterite, definite conjugation, precedes a noun, it assumes the meaning of a participle.

kude'deme coro'mox'	The man that has been killing.
lodoḷ adi'ḷek'	The youth that has been playing.

§ 85. The optative mode expresses, by means of the suffixes *u'ol* or *mi'ebi*, a desire to do a certain thing. Both transitive and intransitive verbs may have this mode. It is conjugated in all forms and in both tenses. The suffixes *u'ol'* and *mi'ebi* are put either between the base and the other verbal suffixes, or between the latter and the first person, present-preterite, of the definite conjugation (see § 82).

āḷ-u'ol' (trans. v.)	to desire to do (the base is *ā*).
mo'd-uol' (intrans. v.)	to desire to sit (the base is *mo'do* but *o* is dropped).
met āḷuol'	I desire to do.
met' mo'duolje	I wish to sit.
met el-ā'ḷuolje	I don't wish to sit.
met āḷ'uolit'	I shall wish to do.
met' mo'duolteye	I shall wish to sit.

u'ol expresses only the *desire*, but not the *possibility* of doing; while *mi'ebi* expresses both ideas. For instance:

1. *met' ḷeñd-uol-je*	I desire to eat, I am hungry.
2. *met' ḷeñde-miebi-je*	I wish to eat (having food).

§ 86. The conjunctive mood is expressed by means of the prefix *ot*:

Met a'nil ai ot'ḷeu	I (once) more fish would eat.
Tet ča'čañin ot'-xo'njek	thou to the elder brother shouldst go.

§ 87. The conditional mood has several forms. The following are all the forms of the verb *ā* (to do):

	1	2	3	4	5		6
met	-*ā'-de*	*ā'-ñide*	*ā'-leḷde*	*ā'-leḷñide*	*ā'ḷ-gene*	or	*ā'-leḷgene*
tet	- "	"	"	"	*ā'-gene*		
tudel	- "	"	"	"	*ā'-deune*	or	*ā'-leḷdeune*
mit	- "	"	"	"	*ā'-ḷukene*	or	*ā'-leḷukene*
tit	- "	"	"	"	"		"
titel	- "	"	"	"	*ā'ñideune*	or	*ā'-leḷñideune*

Forms 1–4 are used when the principal and subordinate clauses have one and the same person as subject, while 5, 6, are used when different person are subjects of the two clauses. Besides, forms 3, 4, and 6 require that the verb in the principal clause shall also be in the conjunctive mood. For instance:

1. *Met ā'-de keit'*	I, if make, shall give.
2. *Met ā'-ñide keit'*	"
3. *Met ā'-lelde met o'tkei*	I, if made, would give.
4. *Met ā'-lelñide met o'tkei*	"
5. *Met ā'lgene, tet mink'*	I, if make, thou take.
6. *Mit ā'-lelukene, o'mni ot'-mi'n·ñam*	we, if made, people would take.

Forms 5 and 6 are also used with the suffix *tel'* of the future tense. For instance:

"*Metul el-ile'-tel-gène,*	*el-ko'ude-tel-gène,*	*met uo'rpe*
me not if wilt scold	not if wilt beat	my children
met'-ti'te yo'uletlelgene,	*te'tin ke'lteye.*" [1]	
me like if wilt love	to thee will go.	

"If thou wilt not scold me, wilt not beat me, my children, like me, wilt love, to thee I will go."

It should be noted in this example that the verbs *i'le* "scold" and *ko'ude* "beat" are in form 5, and *yo'ulețle* "love," in form 6, but without the element of the future tense. The verb *kelteye* (base, *kel'*) (I will go) is in the future tense, indicative mode, and not in the conjunctive *o't-kelteye*, thus corresponding to the first two forms.

§ 88. The supine is formed by means of the suffix *din.*

Met lo'do-din kieče I (in order to) play have come.

This suffix is apparently the dative of nouns. Very often *deñin*, the suffix of the dative case, together with the possessive element, are abbreviated into *din*. For instance, *eme'i-deñin* (to his mother) may be shortened into *eme'i-din*. On the other

[1] Jochelson, Yukaghir Materials, etc., text No. 69, pp. 170, 171, lines 46, 47. Thus a widow replied to a man that was courting her.

hand, the dative of verbal nouns is used instead of the above form of supine. Instead of saying as in the above example, the following expression might be used, *Met lo'doḷ-ñin kie'če.* In this way, the form which corresponds to the Latin supine is rather a substantive than a verbal form.

§ 89. Perfective I called the mode which expresses an absolute certainty that the action will take place. It is formed by means of the suffix *moji'*, which is put between the verbal suffix and the base.

Transitive.	Intransitive.
1. *Met ā'-mojì*	3. *Met' kobe'i-mojì-ye*
2. *Titel ā'-mojì-ñam*	4. *Titel' kobe'i-mojì-ñi*

1. I am able to do, or shall do, without fail.
2. They are able to do, or will do, without fail.
3. I can go away, I shall certainly go away.
4. They can go away, they will certainly go away.

§ 90. The potential mood is formed by means of the prefix *mo'li*, and expresses hope or fear that a certain action will take place. For instance:

Met' mo'li-čo'u	I may cut off, and lest I cut off.
Met' mo'li-el-čo'uye	I nearly cut off.

§ 91. The evidential mood is formed by means of the suffix *lel'*, which is a verbal noun (see § 83) from the verb *le* (to be, exist, live). The evidential mode is used when something is told, not from the experience of the narrator, but (1) from hearsay, (2) as a supposition, (3) as a conclusion drawn from certain traces that the action had taken place, (4) as a dream, and (5) as reminiscences of events which had occurred in the early childhood of the narrator, and of which he had learned subse-

Transitive.	Intransitive.
Met -ā'-lel'	*ū'-leḷ-je*
Tet -ā'-leḷ-mik'	*ū'-leḷ-jek'*
Tudel-ā'-leḷ-um [1]	*ū'-leḷ-i*

[1] The third person, indicative mode is *ā-m·*, but in this case *u* is introduced after the consonant *l*.

quently. Transitive, as well as intransitive, verbs have this mode. Let us take the verbs *ā* (do) and *ū* (be born).

Mit -ā'-leḷ-i	*ū'-leḷ-jèili*
Tit -ā'-leḷ-met'	*ū'-leḷ-jéyemet'*
Ti'tel -ā'-leḷ-ñam	*ū'-leḷ-ñi*
Met eči'e tiñ nu'moḷe ām	My father this house made (the narrator saw).
Met eči'e tiñ nu'moḷe ā'leḷum	My father this house made (it is apparent).
Met eči'e tiñ nu'moḷe ā'leḷum, mo'nñi	My father this house made, they say.
Met yendo'je, met eči'e tiñ numoḷe ā'leḷum	I dreamed that my father this house built.
Tolo'u medi'n pogī'-leḷ-i	A wild reindeer just now ran by (would be said, should fresh traces of reindeer-hoofs be examined on the ground).

"I was born" would be translated, *met ū'lelje* (and not *ū'je*), since no one can be a witness of his own birth.

§ 92. The inchoative mood is formed by means of the auxiliary verb *ā* (to do), which is put between the base and the suffix. Of course the end vowel of the base is frequently dropped in this case. *ā* changes into *e* after *i*.

pa'nde to cook	*pandā'* to start cooking.
ō'je to drink	*ojā'* to begin to drink.
mo'do to sit	*madā'* to sit down (begin to sit).
o'rpo to hang	*a'rpā* to begin to hang.
po'gi to run (of animals)	*po'giā* to start running.

See pp. 101, 102 with reference to *o* changing into *a* in the verbs *mo'do* and *o'rpo*.

Tudel' pa'ndā-i (intrans.), he began cooking. *Tudel ō'jiḷe ō'jā-m* (trans.), he water started to drink.

§ 93. By adding the suffix *yei* to the stem of the verb, an action is expressed for the completion of which it is required to go somewhere. *Yei*, used separately, is a verb whose meaning is to "rush one's self" "to throw one's self."

lo'do-yei to go somewhere, to start off somewhere to play.
kude'de-yei to go somewhere to kill.

It follows the general rules of conjugation of transitive and intransitive verbs.

§ 94. The supine, by means of the auxiliary verb *le* (to be), expresses the readiness, or the intention to do something, and corresponds to the Latin *conjugatio periphrastica.*

keḷdin-le to be getting ready to come, to be ready, to intend to come.
Ti'tel ani'ḷe ḷeu'din-leñi they fish are getting ready to eat.

Voices.

The following voices are formed from transitive and intransitive verbs.

§ 95. The reflexive voice is formed from a transitive verb by means of the personal pronoun *met,* which is prefixed to the verb. In the Slav languages the reflexive voice is formed in the same manner; but the pronoun "self" is used by the latter as a suffix. For instance:

Met' me't-kude'deye	I myself kill.
Tet' me't-kude'deyek'	Thou thyself killest.
Tudel' me't-kude'dei	He himself kills,[1] or killed.

These verbs are conjugated like intransitive verbs.

§ 96. The passive voice is formed from transitive verbs by means of the suffix *o,* which is usually blended, together with the final vowel of the base, into a long *ō*. For instance:

Kude'dō instead of *kude'de-o.*

Verbs in the passive voice are conjugated like intransitive verbs. For instance:

Tu'del' kere'ken·e kude'dō-i He is killed by a Koryak.

[1] It is interesting to note that, in the Tundra dialect, the prefix-pronoun of the reflexive changes by persons, as in the Romano-Germanic languages:

Met' met-bunje	I kill myself.
tet' tet-bun-jek'	Thou killest thyself.
tudel' tur-bun-i	He kills, or killed, himself.

§ 97. The causative voice is formed, by means of the suffix *c*, from transitive as well as intransitive verbs; but the latter are, in such cases, changed into transitive verbs:

kude'de-c	to cause to kill.
mo'do-c	to make to sit.

There is another suffix for the formation of the causative voice; namely, *ctile*; but the difference between the two is not quite clear to me as yet. I hope that closer study of the texts will make the difference clear.

§ 98. The reciprocal voice is formed by means of the prefix *n·e* (in nouns, it constitutes the suffix of the comitative case). This voice follows the rules of conjugation of intransitive verbs. For instance:

Ti'tel n·e'kudèdeñi	They killed each other.

§ 99. The coöperative voice is formed by means of the suffix *je* or *ji*. For instance:

kude'je	To kill together.

kudeje is equivalent to *kudedeje*. The second syllable *de* is blended together with *je* into one syllable.

Aspects or Degrees of Action.

§ 100. Derivative verbs indicating degrees of action are formed by means of suffixes, except those in § 107.

§ 101. The suffix *i* indicates singleness of action, that a certain action was performed only once and within a short period of time:

pa'nde to cook	*pa'ndei* to cook once.

§ 102. The suffix *či* expresses an action in diminutive form, limits the volume of it:

pa'nde-či	to cook a little.

§ 103. The suffix *nu* expresses the iterative form of the action:

pandā'-nu	to cook several times.

In this case, the final vowel of the base turns into a long sound.

§ 104. The suffix *nunu* (a reduplication of *nu*) expresses the iterative form in an intense degree :

pandā-nunu	to be always cooking (with interruptions).

§ 105. The suffix *yi* expresses the durative form, indicating continuity of action, or its reiteration within certain periods of time :

panda'-yi	to cook long.
Met ā'če ku'deči	I killed many reindeer one after another.

ku'deči is equivalent to *kude'de-yi*. The *e* is dropped in *de*, and *dy* is *j* (see phonology), *j* changes into *č*(*ty*).

§ 106. Any two of the enumerated suffixes for the expression of degrees of action may be combined, thus forming the following:

1.	*inu*	the repetition of a single action.
2.	*inunu*	" " " "
3.	*činu*	the repetition of a diminutive form, diminutive-iterative.
4.	*činunu*	" " " " " "
5.	*yinu*	durative-iterative.
6.	*yinunu*	" "

§ 107. The prefix *me* expresses an action not quite completed but in the process of completion, or recently completed, or about to be completed :

Met āče me'-kude'de	I have just been killing, or I am killing a reindeer.
Met' me'-lodo'teye	I am going to play, I will play, right now (soon).

§ 108. The order in which the suffixes expressing the different derivative conceptions are arranged after the verb-base is as follows : base + voice + degree of action + mode + verbal suffix of person and tense :

Tu'del āc-nu'-leḷ-um	He apparently caused to do . . . several times.

§ 109. Before proceeding to describe the participial forms, I wish to draw attention to the ease with which nouns become verbs, outside of the cases mentioned above (see § 64).

§ 110. Every noun in the comitative forms, by dropping *e* of its suffix *n·e*, a base of an intransitive verb expressing the ownership of something. For instance:

āče-n'·e	with reindeer.
ā'čen·	to have reindeer.
Met āčen·-je	I have reindeer, or a reindeer.
met uo'rpen·-je	I have children.
Tu'del eči'en·i	he has a father.

§ 111. Every base of a noun may be turned into an intransitive verb by adding to the particle *ño* (be) as a suffix, which has no meaning when it stands alone. For instance:

Eči'e-ño	be a father.
Met ečie-ño-je	I am a father, I have been a father.
Met eči'e-ño-teye	I shall be a father.

Verbal Nouns.

§ 112. The particle *bon*, being suffixed to various verbal forms, composes verbal nouns, which are used sometimes as the name of the subject (like our participles), or as a name of an action; but if the verb is transitive, the verbal noun may also signify the object which receives the action expressed by the verb. From the base *ōje* (to drink), we may derive the following verbal nouns:

Present-Preterite.

ō'jeyebon *ō'jemebon* *ō'jemeḷebon* *ō'jeḷbon*

Future.

ō'jeteyebon *ōjetmebon* *ōjetmeḷebon* *ojeteḷbon.*

Bon combines also with the form *lel'* of the evidential mode.

Examples.

1. *Tu'del i'bičiḷe ō'jemeḷebòdek'* He the milk who drank, or it is just the one that drank the milk.

ō'jemeḷebòdek' is the definite nominative case of *ō'jemeḷebon* — One who drank.

2. *Met ō'jelbon ō'jik'*	my (by me) drunk water, the water (that I am drinking) drunk by me.
3. *Met ōjeḷbon* *Met ō'jeyebon* *Met ō'jemebon*	my beverage, or the beverage that used to be mine.
4. *Ōj'e-nu-meḷebòngeḷe* (accus.) *nèx'anin el mi'ji*	That which is used to drink (he) has never taken.
5. *Metek ō'jeteyebodek'*	I am the one that will drink.

The suffix *bon* is used as an independent word, *pon* (a word cannot begin with *b*). In olden times this word used to indicate the name of a deity embracing all nature, the universe. *Pon* indicates *something that is unknown.* All household goods taken as a whole are spoken of as *po'npe.*

§ 113. The suffix *uo* or *uol'* (from *uo*, "child"), when joined to verbal forms, expresses the result of an action. For instance:

xo'n-uo or *xo'n-uol'* (from *xon*, "walk"),	walking, a trace from walking, also a trail.
ō'je-l-uol' (*l* is introduced between the two vowels; *ōje* is the basis of the verb "drink")	the process of drinking, also the trace left from drinking, *e. g.*, the water left in the glass after drinking.

§ 114. With regard to verbal forms serving as adjective modifiers, see §§ 80, 84, 110.

The Gerund or Verbal Adverb.

§ 115. The suffix *t*, together with the verbal base, forms the verbal adverb, which expresses an action taking place simultaneously with that indicated by the predicate:

Met' mo'do-t a'yi	I while sitting was shooting.
Met anil ḷegu-t' coriḷ'e	I while eating fish was writing.

It seems to me that the suffix *t* is that of the ablative without the local element *ge* (§ 12):

Mo'do-t'	sitting, or from sitting.

§ 116. The suffix *ḷḷe* with the verbal base expresses an action preceding the one expressed by the predicate. *ḷḷe* is apparently nothing but the instrumentative case *ḷe* (see § 12); but I always heard a sound of double *ḷ* in verbal adverbs. This form is in most cases combined with the possessive element *de* or *do* (see § 12):

Met e'ye ā-deḷḷe nu'mo-yekli'n xo'nje	I, a bow having made, went hunting.
Met' modā'-deḷḷe mo'go i'gdā	I, having sat down, a cap began to sew.

§ 117. If the verbal adverb expresses an action of another person (not of the subject), but taking place simultaneously with the action of the subject, it is then derived from the forms of the definite conjugation (see § 82) together with locative suffixes. The suffix *ge* is used for the first and second person, singular number; *dege*, for the third person, both numbers; and *ḷuke*, for the first and second person, plural number. For instance:

Met yu'oḷ-ge	while I looked.
Tet yu'ol-ge	while thou looked.
Tu'del yu'o-dege	while he looked.
Mit yu'oḷuke	while we looked.
Tit yu'oḷuke	while you looked.
Ti'tel yu'oñi-dege	while they looked.
Mit yu'oḷuke tu'del ani'ḷe i'gdem	while we looked (in our looking), he was fishing.
Ti'tel ai yo'nḍoñide'ge mit ánil i'dgei	while they were still asleep we were catching fish.

The Adverb.

§ 118. The following are some of the adverbs of time:

xani'n when.	*ti'ne* lately.
xani'nde sometimes.	*čugo'n* soon.

ajōn' early.
tudā' long ago.
ič long.
xo'nlume, xo'llume immediately.
n·e'xanin never.
xa'dič already.
a'ñnume at first.
ke'yot' at first.
keye'n previously.
druk' (suddenly, the Russian word *vdrug*).
tāt, tā'čile afterwards, later on.
ne'gajiye yesterday.
ogo'iye to-morrow.
ta'ñnugi then.
i'ji now.
ai again, once more, anew.
Ta'bun-ni'ñiñ-gièlgc meanwhile, in the mean time.
ni'ñelije many times.
xa'mlije several times.

§ 119. Adverbs of place:

tā there, thither.
tī here.
xon where, whither.
xot where from, whence.
xo'dibonget' whence.
xo'nde eyerywhere, anywhere.
tāt' thence.
iñer elsewhere.
migi'de hither.
tiñide this way.
cai'rude sideways.
pude outside.
n·ačin against, opposite.
tīt' hence, from here.

§ 120. Adverbs of manner:

o'moč well.
čomo'n very.
n·a'dude enough, only.
ta'ñdaga enough.
ki'juon· easily, lightly.
nige'yot heavily.
i'rkin only.

§ 121. All adverbs directly precede the verb, and may be regarded as prefixes. Not all adverbs to be found in the language have been enumerated here. Some adverbs are simply roots, for instance, *tā, ti.* Others are derived from these roots, for instance, *tāt' tīt'* ("thence," "hence"), which are the ablative of *tā* and *tī.* Others are formed from nouns and adverbs, as, for instance, *n·'ačin* ("opposite"), an abbreviation of *n·'ačeñin* (dative of *n·a'če,* "face"); *i'rkin* ("only") is merely the numeral *one ; čomo'n·* ("very"), from *čomo,* which is the basis of the intransitive verb *to be large.*

§ 122. The temporal case of nouns, mentioned under nouns, is also to be added to the adverbs of time (§§ 12, 31).

Post-Positions.

§ 123. All post-positions, which take the place of prepositions, might just as well be called "case-post-positions," like the suffixes enumerated in connection with the declension of nouns (see § 1). Post-positions differ from the latter in that they are not used in connection with a possessive element, and that most of them may take on case-suffixes. The latter circumstance is not so characteristic, however, since *n·e*, comitative case, is used as a separate word, *n·a'ga* ("together"), and the case-suffixes *get*, *gen*, *gete*, are derivatives from the locative *ge*. As may be seen from examples, post-positions are sometimes put after oblique cases of nouns.

§ 124. The following are the post-positions.

yoḷa', *yoḷa'n* after, behind.	*Met-yoḷa'* after, behind me.
budi'e on top, upon, on.	
budi'en on, over the surface.	*Tu'delʿ nu'me-budi'emo'doi* he sits on the house.
budi'etʿ from under the surface.	
āl under.	*met-āl* under me.
āt from under.	*lebie'-n-āt u'koč* came out from under the ground.
alā' near.	*nu'mo-d-alā'* near the house.
ca'ide across.	*unu'ñge-ca'ide* across the river. *u'nuñ* (river) *ge* is in the locative case.
yekli'e behind.	*nu'mon-yekli'e* behind the house.
mekli'e in front.	*u'nuñ-mekli'e* at this side of the river.

let for the sake, is a verbal adverb of the verb *le* ("be"), and is put after the dative.

met eči'eñin-letʿ kole'če	I for the sake of father came.
ele-ču'on without.	*E'le* (the adverb of the denial *no*) is put before the noun.
Ti'tel e'le-me't-ču'on xo'ññi	They without me went away.

§ 125. The Yukaghir language has no conjunctions; but some pronouns in oblique cases are used instead. For instance,

Tabu'nget' (ablative of *ta'bun*, "that") replaces the illative conjunction *therefore*.

Ta'tmedeu'ne ("and for this reason") is the subjunctive mode of the intransitive verb *tatme* ("to be such").

The adverb *ai* ("again") is sometimes used instead of our conjunction *and*:

Ti'tel ya'xteñi ai lo'ñdoñi They sang and danced.

CONCLUDING REMARKS.

The morphological peculiarities of the language may be summed up in the following main propositions.

Word-formation is accomplished mainly by means of suffixes; but prefixes are also used (almost exclusively in connection with verbal forms). In this respect the language differs from those of the Ural-Altaic group, which use suffixes only, and approaches the American languages.

The possessive suffixes of nouns is but little developed (except in the third person); the language thus differing from the Ural-Altaic, as well as from the Eskimo dialects.

Sound harmony of vowels (*a* and *o* should not occur in the same word), is little developed, and in this respect the language resembles some of the Indian dialects, but differs absolutely from the Ural-Altaic languages with their intricate system of vowel-harmony. For instance, an important feature of the vowel-harmony of the latter group of languages consists of the adaptation of the suffix vowels to the vowel of the root, which never changes. The vowel of the first syllable thus governs all the rest of the vowels, no matter what their number may be. In the harmony of the Yukaghir language, the root-vowel frequently adapts itself to the vowel of the suffix (see § 92). Besides, in the plural forms of personal pronouns (*met'*, *mit'*; *tet'*, *tit'*; *tudel'*, *titel'*) an attempt may be noticed in the language to derive new forms by means of changes of vowels within the root (the method of Semitic languages) without any additions from outside, a feature of which traces may be found in two other so-called "isolated" Siberian languages, — that of the Kott and the Ostyak from Yenisei.

The difference in the conjugation of transitive and intransitive verbs which we have in the Yukaghir language is a feature common to almost all American languages. The same may be said of the capacity of bases of transitive verbs to change into intransitive by means of suffixes and *vice versa.*

Suffixes of purely verbal forms are different from case-suffixes, and they cannot be brought in connection with personal pronouns.

A necessary element of plurality is constituted by the sound *p*; while that of futurity by *t*. In the Chukchee and Eskimo languages *t* constitutes the element of plurality, and in the Koryak language it forms the element of the dual number.

Adjectives, being verbal forms, do not undergo any inflections.

There is no difference between animate and inanimate objects, as is the case in some Indian dialects.

The feature known as "polysynthesis" in American dialects, and which consists of a combination of two or more uninflected bases in one word, in which one of the bases expresses the principal idea, and is put at the end of the word, while the other bases figure as secondary definitive ideas, is also to be met with in the Yukaghir language. For instance:

Met	*tu'de-eji'e-*	*mo'dol'-*	*koi*	*-cu'oleji*	*pundut'*[1]
I	he self	sitting	boy	tale	shall tell.

That is, I shall tell a tale of a boy who was sitting (living) all alone.

In the expression:

tu'de-eji'e-mo'dol'-koi-ču'oleji

we have an actual synthesis. Without being inflected, all secondary bases are combined into one conception with the principal base *ču'oleji-tale*

Or: *Ye'lokun-*	*no'ineye-*	*bon*	*-ku'dečiye*	*eoro'mo-ñot'*	*kude'ye*[2]
Four	with legs	something	killing	man-being	have become.

[1] See Yukaghir Materials, etc., Tale 12, p. 25.
[2] Ibid., Tale 25, p. 169.

That is, (I) have become a man that kills four-legged things (animals).

Other examples may be cited in which the bases combining into one word drop one or more syllables. For instance: *Čo'māni* (*Coregonus leucichtys*) is actually derived from *Čomo'je-d-a'nil* ("big fish"); or *Čomō'čie* (elder brother of the father, uncle) is really *Čomo'je-d-eči'e* (big father).

It is true that there is no actual incorporation to be found in the language; neither pronouns nor nouns, when direct or indirect objects, are incorporated in the predicate; but the nature of the syntactical construction of the Yukaghir language is akin to incorporation. The verb plays the main part in the sentence. It is always placed at the end of the sentence, being preceded, first by the subject with all its modifiers, then by the direct and indirect objects with their modifiers, then by the adverbs. If the subject is not accompanied by any modifiers, and it is known from the sense of the story who the acting person is, then it is usually dropped (see below, the text). The subject very often does not assume the element of plurality, though there are many acting persons, as long as the sense of plurality is expressed by the verb (see the text).

APPENDIX.

A Tale of what the Ancient Yukaghir did with their Dead Shamans.

1	2	3	4
Ču'oḷe-d-o'mni,	*a'ḷmaḷe,*	*a'mdegene,*	*ču'de*
Ancient people	the shaman's,	when (he) died,	flesh

5	6	7	8
ḷo'ndomiebìde,	*ca'rxun-molo'ǰek*	*mo'roñimeḷe,*	*n·a'če-n-abu'tek*
to separate wishing	gloves	put on	masks

9	10	11	12	13
mo'roñimeḷe	*ḷu'dud-ū'nik'*	*mı'n·ñimeḷe.*	*Tabu'de,*	*ču'deuḷe*
put on	iron hooks	took.	Therewith	flesh his

14	15	16	17	18
n·e'čaxadàideḷḷe,	*tı'te-làñi*	*āči'yıñam.*	*Tāt'*	*či'ñǰit*
having caught	to them	drew.	Thus	having drawn

19	20	21	22	23	24
čo'ñnuñam.	*Nugo'ne*	*e'le-me'inuñi.*	*N·e'ḷbetñam,*	*tāt'*	*n·um'ǰit*
cut.	With hands	not took.	Tore off	thus	whole

25	26	27	28	29	30
ke'nbunit'	*ḷondoñam.*	*O'rponǰirax*	*ā'ñimeḷe,*	*pu'de*	*ā'ñam,*
entire width	separated.	Hangers	made	outside	made

31	32	33	34	35	36
tā	*orpu'reñam;*	*pu'de,*	*yeloǰ'eñin*	*kie'lecñam.*	*Kie'lecteḷḷe*
there	hanged	outside	in the sun	dried.	Having dried

37	38	39	40	41
coro'mon·ulpegi	*le'ñitei,*	*ta'ñde*	*ču'ḷgeḷe*	*xa'rteñitem.*
relatives his	if will be	that	flesh	will divide.

42	43	44	45	46
O'nmedie-nu'mok	*ā'ñimeḷe.*	*Ti'te*	*pa'ilgeḷe*	*o'nmedie-nu'mo*
Of thin larch a house	made.	Their	shares	of thin larch house

47	48	49	50	51
mo'ḷgodo'go	*caxa'lecñam*	*ni'ñer.*	*Coro'mon·ulpegi*	*tobo'koḷok'*
middle	put (every one)	separately.	Relatives his	dogs

52	53	54	55	56	57
ku'dečiñimeḷe,	*er'če*	*tobo'kogeḷe*	*e'le-ku'dečiñi,*	*omo'če*	*tobo'kox'*
killed	bad	dogs	not killed	good	dogs

58	59	60	61	62
ku'dečiñimeḷe.	*Tabu'ngeḷe*	*ti'te*	*pai'lge*	*poni'yiñam.*
killed.	Those (dogs)	to their	shares	put.

63	64	65	66	67
Tabu'de	*ke'nmeteḷḷe,*	*po'niñam.*	*A'mundeuḷe*	*ta'bun-yōḷa'n*
Those	having added	left.	Bones his	thereafter

68	69	70	71
xa'rtā'ñam.	*Tabu'dek*	*amu'ngi*	*kie'lecteḷḷe*
to divide commenced.	Those	bones his	having dried

72	73	74	75	76
tamit'eñam.	*Tabu'de*	*yō'd-amu'ngeḷe*	*xo'ideñi.*	*Tabu'ngeḷe*
clothed.	That	his skull	worshipped.	For that

77	78	79	80	81	82
cāḷek'	*coro'mo-ti'te*	*ā'ñam,*	*coromodeuḷe*	*coromo-titelu'o*	*añam.*
(of) wood	manlike	made	trunk his	manlike	made.

83	84	85	86	87
Yō'-d-amu'ndeuḷe	*tā*	*nuce'lecñam.*	*Tabu'ngeḷe*	*ma'gideuḷe*
His skull	thence	set on.	For that	jacket his

88	89	90	91	92	93
u'yāñam,	*mo'gopedeuḷe*	*ā'ñam.*	*Ta'ñde*	*n·e'rgeḷe*	*ceu'reñam,*
made	caps his	made.	That	garb his	embroidered,

94	95	96	97	98
e'le-kie'-ču'on	*ceu'reñam.*	*Ti'ñde*	*n·a'čedeuḷe*	*n·e'rek*
all over	embroidered.	For this	for his face	clothes

99	100	101	102	103	104
u'yāñimeḷe,	*a'ñjeduol'-*	*pon·xobodek*	*ā'ñimeḷe,*	*a'ñadeuḷe*	*ai*
made	for eyes	openings	made	mouth his	also

105	106	107	108	109
ā'ñam.	*Ti'ne*	*coril'en·ul'*	*ma'gideuḷe*	*pu'dedegen*
made.	Former	embroidered	jacket his	on it

110	111	112
yero'ye-xar-magi'ḷe	*moru'ceñam.*	*Ta'bun*
of skins of one year old reindeer jacket	put on.	That

113	114	115
pu'dedegen	*no'ɨin·ere*	*yodu'taiñam.*
upon (of it)	(with) blanket of soft reindeer-skin	wrapped.

116	117	118	119
Tā'čile	*modo'toñam,*	*o'rje*	*modo'toñam.*
Thereafter	set (also placed)	in the front corner	placed.

120	121	122	123	124
Omo'čebon	*ḷe'ññide,*	*ḷoči'ḷge*	*pe'deteñam,*	*pu'dedegen*
Good something	if eat	in fire	burn	over it (fire)

125	126	127	128	129	130
tabu'ngeḷe	*tā*	*mo'inunuñam :*	*Ta'ñde*	*me'-ḷegiteñam,*	*ka'cnei*
that	there	keep :	That	so fed	at every

131	132	133	134	135
ḷe'ñdeḷge	*tāt*	*ā'ñam.*	*Tabu'de*	*xo'in·eñi.*
meal	thus	did.	That (one)	worshipped.

Told by the old Yukaghir Nicholas Samsonoff in the village on the Korkodon River, October, 1896.

Free Translation of the Text.

Our ancient people, when a shaman died, used to separate the flesh of the corpse from the bones. For that purpose they put on gloves and masks. Then they took iron hooks, and, having caught the flesh of the corpse, drew it to them and cut it off. It was considered a sin to touch the corpse with bare hands, or to look at it with uncovered face. Thus they separated the flesh from the skeleton on its entire length. Then they made drying-frames and hung the flesh on them outside, in the sun to dry. After the flesh was dried, the relatives of the dead

shaman divided it among themselves. Then they made a tent of thin larch-trees, and each of them put his share in the middle of the larch-tent separately. Then the relatives of the shaman killed dogs as offerings. They did not kill bad dogs; they killed only good ones. Then they added the killed dogs to their portions of dried flesh. After that they left the tent with the shaman's flesh and the dog-offerings.

Then they divided the bones of the corpse, and, after having dried them, they clothed them. They worshipped the skull of the shaman. They made a trunk of wood, and set on it the skull. Then they made for it (for the idol) a jacket and caps (two caps, — a winter and a summer one). They embroidered the coat all over. For its face they made a mask, with openings for eyes and mouth. Over the embroidered coat they put a coat of fawn-skins; and over that, a blanket of soft reindeer-skin.

Then they placed the figure in the front corner of the house. Whenever they were going to eat something good, they first threw a piece of it into the fire, and held the figure over the smoke. This they did at every meal; and thus they fed the figure, which they worshipped like a god.

Grammatical Analysis of the Text.

1. *Ču'oḷe-d-o'mni.* *Ču'o,* adverb of time (*long* ago); *ču'oḷe* (old times); *o'mni,* a collective conception (people, men). It was apparently formed from *ó'mo* (tribe, clan, kin) and the suffix comitative *n·i* (instead of *n·e*) (with the kin, with the entire clan). *Cu'oḷe-d-o'mni* (people of times ancient). See § 9.

2. *A'ḷmaḷe.* The base is *aḷma* (shaman); *ḷe* is the suffix, accusative indefinite. See §§ 12, 20.

3. *A'mde-gène.* *Amde,* base of intransitive verb (*die*); *gene* is the suffix of the conditional mode. See § 87.

4. *Čude* is used instead of *čugi.* The base is *čuḷ* (meat, flesh); *gi* is the possessive suffix (see §§ 8, 9); *ḷ* before *gi* is usually dropped. The use of *de* instead of *gi* is apparently an old form. It occurs in ancient tales and shaman's songs, but not in ordinary conversation.

5. *Lo'ndo-miebi'-de.* *Lo'ndo*, base of transitive verb (separate); *miebi*, optative mode (see § 85); *de*, suffix of the conditional mode (see § 87). This verb has formally two direct objects — *alma-le* and *ču'gi* — instead of *a'lma-ču'gi* (the shaman's flesh).

6. *Ca'rxun-molo'jek* (gloves), from *ca'rxun* (fingers) and *molo'je* (mittens, mittens with fingers), *k*, suffix of accusative definite case. See §§ 12, 20.

7. *Mo'roñimele.* *Mo'ro*, base of transitive verb (put on); *ñimele*, suffix of the third person, plural number, present preterite, definite conjugation (see § 82). *Ca'rxun-molo'jek* is in the singular number, since in the Yukaghir language it is sufficient if the idea of plurality is expressed in the predicate only.

8. *N·a'če-n-abu'tek'* (mask), from *n·a'če* (face), *a'but'* (cover); *k*, suffix of the accusative definite (§ 12); *n* is inserted between the *two vowels.* See § 9.

9. See 7.

10. *Lu'du-d-ū'-nik'* (iron hook). *Ludul'* (iron), *l'* is dropped; and *ū'ni* (hook); *k*, suffix of the accusative definite; *d*, see § 9.

11. *Mi'n·ñimele* (took). *Min·*, base of transitive verb (take); *ñimele* (see 7).

12. *Tabu'de* (therewith, with that; that is, with the hooks). The base is *Ta'bun* (that). *Tabu'de* (inst. of *tabu'nle*), instrumental case (see § 60).

13. *Ču'deu'le* (flesh his; that is, the shaman's). The base is *čul'* (flesh), *l'* is dropped before *d*; *deule* = *degele*, accusative definite with the possessive element (see § 26).

14. *N·a'čexadaìdelle* (having caught). *Na'cexada* (catch), transitive verb; *i*, the element indicating singleness of action (see § 101); *delle*, suffix of the verbal adverb, past tense (see § 116).

15. *Ti'te-lañi*, to them, *Ti'te*, instead of *titel'* (they), *l'* being dropped; and *lañi*, a post-position indicating direction toward something.

16. *Āči'yiñam*, from *ā'či* (to draw), base of transitive verb; *yi* durative (see § 105); *ñam*, third person, plural number, present preterite, transitive verb, indefinite conjugation (see § 75).

17. *Tāt'* (thus, after, or thence) is formed from *tā* (there). See § 119.

18. *Ci'ñjit* (having drawn, pulled). *Ciñ* (pull, draw), base of transitive verb, it has apparently the same root as *ā'či* (16); *ji*, suffix co-operative (see § 99); *t*, suffix of present participle (see § 115).

19. *Čo'ñnuñam* = *čo'uńuñam*, from *čo'u*, (cut) base of transitive verb; *nu*, suffix of the iterative form (see § 103); *ñam* (see 16).

20. *Nugo'ne*. *Nu'gon* (hand), base; *e*, instead of *ḷe*, suffix of the instrumental case. *ḷ* is dropped after the final *n*; in some cases, the final *n* is changed into *d*, f. c. *nugo'de* inst. of *nugo'ne*.

21. *Ele-mei'nuñi* = *ele moinuñi*. *Moi* (to hold), base of transitive verb; *nu*, suffix of the iterative form (see § 103); *ele* (or *el*) . . . *ñi*, prefix and suffix of the negative conjugation (see §§ 75, 79).

22. *Ne'ḷbetñam*. *Ne'ḷbet* (to tear off, to skin, to pull off the skin), base of transitive verb; *ñam* (see 16).

23. *Tāt*. See 17.

24. *N·u'mjit* (whole, entirely), *gerund* (see § 115), from *nu'mḍe* or *nu'mje* (be whole); *nu'mjeye n·e'molgiḷ'*, a whole year (see § 80).

25. *Ke'nbunit'* (entire width), *gerund* (see § 115), from *ke'nbun*. (be wide); *ke'nbuneye-d-u'nuñ*, wide river.

26. *Ḷo'ndoñam*. *Ḷo'ndo* (separate, untie), base of transitive verb; *ñam* (see 16).

27. *Orpo'njirax* (hangers). *X*, suffix of accusative definite (see §§ 12, 20). This word is formed from the base of the intransitive verb, *o'rpo* (hang); *n* is inserted *ji*, suffix coöperative (see § 99) and *caḷ* (tree), *ḷ* having been dropped, and *c* changed into *r*.

28. *Āñimeḷe*. *Ā* (do), base of transitive verb; *ñimeḷe* (see 7) is in agreement with the definite case (see 27). See §§ 82, 83.

29. *Pu'de* (outside), adverb.

30. *Ā-ñam*. *Ā*, see 28; *ñam*, see 16.

31. *Tā* (there), adverb (see § 119).

32. *Orpu're-ñam*. *Orpu're* (hang), base of transitive verb; *ñam*, see 16.

33. *Pu'de.* See 29.

34. *Yelo'je-ñin.* *Yelo'je* (sun), base; *ñin* (to the sun), suffix dative (see § 15).

35. *Kie'lec-ñam.* *Kie'le* (be dry), base of intransitive verb; *c*, suffix of the causative voice (see § 97), *kielec* (make dry, force to be dry); *ñam*, see 16.

36. *Kie'lec-telle.* *Kie'lec*, see 35, *telle* = *delle* (*d* after *c* changes into *t*), see 14.

37. *Coro'mon·ul-pe-gi.* *Coro'mon·ul'* relative; *pe*, element of plurality (see § 33); *gi*, possessive suffix (see §§ 7, 12).

38. *Le'-ñitei.* *Le* (be), base of intransitive verb; *ñitei*, suffix of the third person, plural number, future tense, indefinite conjugation of intransitive verbs (see § 75). The future tense is sometimes used instead of the conditional mode.

39. *Tañ-de*, instead of *tañ-le.* *Tañ*, demonstrative pronoun; *de*, suffix of accusative indefinite (see § 60).

40. *Ču'l-gele.* *Čul* is the base; *gele*, suffix of the accusative with the possessive element (see §§ 12, 25).

41. *Xa'rte-ñitem.* *Xa'rte* (divide), base of transitive verb; *ñitem* suffix of the third person, plural number, future tense, indefinite conjugation of transitive verbs (see § 75).

42. *O'nmedie-nu'mok* (a house made of young larch-trees; that is, a conical tent made of larch-tree rods). *O'nmedie* is formed from *on*, a root expressing the conception of larch. Larch-tree is called *o'nra* or *onda*; that is, *on* (larch) and *cal* (tree), see 27; *di'e* is the suffix of a diminutive noun (see § 39); the meaning of the particle *me* is unknown to me. It is, at any rate, hardly possible that we should have to do here with the word *o'nme* (mind, memory, or opinion). *Nu'mo* (house); *k* suffix of the accusative definite (see § 12).

43. *Ā'-ñimele.* *Ā* (to do); *ñimele*, see 7.

44. *Ti'te*, possessive pronoun (see § 55).

45. *Pa'il-gele.* *Pail* is from the Russian word *pai* (share): *l* has apparently been added either to form a Yukaghir verbal noun out of the Russian base, or in order to distinguish it from the Yukaghir word *pai* (young woman); *gele* (see 40).

46. *O'nmedie-nu'mo.* See 42.

47. *Mo'lgo-dògo* (in its middle). *Mo'lgo,* adverb of place, also used as a post-position; *dogo = dege,* suffix of the locative with the possessive element (see § 12).

48. *Caxa'lec-ñam.* *Caxa'lec* (assemble, gather, rally, collect), base of transitive verb; *ñam.* See 16.

49. *Niñer* (every, separately), from *i'ñer* (separately) and *n·e* (together). See §§ 119, 123.

50. *Coro'mon·ulpegi.* See 37.

51. *Tobo'ko-ḷok'.* *Tobo'ko,* from the Russian *soba'ka* (dog). Since there is no sound of *s* in the Yukaghir language, *s* is changed into *t,* and both vowels *a* changed into *o,* according to the rules of harmony (see Phonology). The ancient word for dog, *pu'bel'* is not used any more. The Tundra dialect still retains two words for dog, — *ḷameñ* (this word seems to be borrowed from the Tungus) and *xapn·eñ*; *ḷok' = ḷek',* suffix of the accusative definite (see § 12).

52. *Ku'de-či-ñimeḷe* is formed from the base *kude'de* (to kill); *yi,* suffix of the durative form; *de + yi = či* (see § 105); *ñimeḷe,* see 7.

53. *E'rče* (bad, poor), first person, singular number, present-preterite (base *e'ru-* be bad), used as an adjective before a noun (see §§ 37, 80).

54. *Tobo'ko.* See 51; *geḷe,* see 40.

55. *E'le-ku'deči-ñi.* *Ku'deči,* see 52; *e'le . . . ñi,* form of the third person, plural number, present preterite, negative conjugation of transitive verbs (see §§ 75, 79).

56. *Omo'če,* from *o'mo* (be good), the base of the transitive verb; *če,* see 53.

57. *tobo'ko,* see 51; *x',* suffix of the incomplete indefinite form of the accusative (see § 12).

58. *Ku'dečiñimeḷe.* See 52.

59. *Tabu'ngeḷe.* *Ta'bun* (that), see §§ 56, 60; *ge'ḷe,* see 40.

60. *Ti'te.* See 44.

61. *Pail.* See 45; *ge,* suffix of the locative (see §§ 12, 16).

62. *Poni'-yi-ñam.* *Po'ni* (put), base of the transitive verb; *yi,* see 16 and 52; *ñam* (see 16).

63. *Tabu'de,* instead of *ta'bun* (the base of the demonstrative

pronoun that), and *le*, suffix of the accusative definite (see § 60).

64. *Ke'nmete-lle.* *Ke'nme* (friend) changes, by means of the suffix *te*, into a transitive verb, — *to provide someone with a friend, a companion*, or *fellow-traveler* (see § 64); *lle*, suffix of the verbal adverb, past tense (see § 116, and compare with the element *de* in 14).

65. *Po'ni-ñam.* See 62.

66. *A'mun* (the base, means bone); *dèule.* See 13.

67. *Ta'bun.* See 63; *yola'n* (after, behind), post-position see § 123).

68. *Xa'rtāñam* = *xa'rte* (see 41) + *ā*, inchoative mood (see § 92); *ñam.* See 16.

69. *Tabu'dek'*, instead of *tabunlek'* (see 63, the accusative definite (see § 60).

70. *A'mun.* See 66; *gi*, possessive suffix of the accusative.

71. *Kie'lectelle.* See 36.

72. *Tami'te* (to dress, dress up), base of transitive verb; *ñam.* See 16.

73. *Tabu'de.* See 63.

74. *Yō'-d-amu'ngele* (the head-bone; that is, skull); *yō* (head); *d* is inserted for euphony (see § 9); *a'mun.* See 66; *gele.* See 40.

75. *Xo'ide-ñi.* *Xo'ide* or *xo'in·e* is the base of the intransitive verb to *have a god* or to *be with a god*, from *xoil'* (god) and the suffix *de* (see § 64) or *n·e* (see § 110); *ñi* is the suffix of the intransitive verb (see § 75). It should be noted, that with the intransitive verb *xo'ide* a direct object in the accusative has been used. It might have been the instrumentalis, *tabu'de yō-d-amu'ngele;* that is, with this skull (see § 60) they were as with a god (see 134, 135).

76. *Tabu'ngele.* See 59, in the sense of "for that"; that is, for the skull.

77. *Cā'l-ek'.* *Cāl* (tree); *ek'*, instead of *lek'* (*l* having been run into one with the *l* of the base), suffix of the accusative definite (see § 12).

78. *Coro'mo* (man); *ti'te*, suffix of the comparative II (see § 12).

79. *Ā'-ñam.* See 30. It should be pointed out that the

word *ā'-ñam* has two objects in the accusative. One (76) is in the definite; the other (77), the indefinite form.

80. *Coro'mo* (man and trunk, body), in this case it means trunk; *deuḷe = degeḷe.* See 13.

81. *Coro'mo-titelu'o.* See 78. *Coro'mo-tite-l-uo* figures here as the suffix of the verbal noun, indicating the result of an action (see § 113).

82. *Ā'-ñam.* See 79.

83. *Yo'-d-amun-dèuḷe.* See 66 and 74.

84. *Tā.* See 31.

85. *Nuce'lec-ñam. Nuce'lec* (set on); *ñam.* See 16.

86. *Tabu'ngeḷe.* See 59.

87. *Ma'gi-dèuḷe,* from *ma'giḷ'* (coat, jacket), *l'* being dropped, and *deuḷe = degeḷe.* See 13.

88. *Uyā'ñam = u'i* (work); *ā,* inchoative mood (see 68); *ñam.* See 16.

89. *Mo'go* (cap); *pe,* element of plurality. Two caps used to be made, — one for the summer, made of soft reindeer leather and embroidered; the other one, made of fur, was put on top. *ñam.* See 16.

90. *Ā'-ñam.* See 30.

91. *Ta'ñ-de = ta'ñ-ḷe,* the accusative indefinite (see § 60).

92. *N·er* (garb, things); *geḷe.* See 74.

93. *Ceu're* (to embroider); *ñam.* See 16.

94. *E'le-kie'-ču'on = e'le . . . ču'on* (without), see § 124, and *ki'čil'* (end). *čil'* is dropped, and *i* is lengthened into a diphthong. Without end; that is, entirely, all over, nothing was left unembroidered on the garment.

95. *Ceu'reñam.* See 93.

96. *Ti'ñ-de = ti'ñ-ḷe* (this), the accusative indefinite (see § 60).

97. *N·a'če* (face), see 8; *deule,* see 13.

98. *N·er-ek. N·er,* see 92; *ek,* suffix of the accusative, instead of *k, e* being inserted after the final consonant of the base. It seems to me that the accusative in 97, in its relation to *n·er-ek,* is used in the sense of the Saxon form of the genitive case in the English language.

99. *Uyā',* see 88; *ñimeḷe,* see 7.

100. *A'ñje-d-u'ol'* = *a'ñje* (eye); *d*, the connecting particle; *uol'*, the suffix of a verbal noun expressing the result or trace of an action (see § 113). *A'ñje-d-u'ol'* = place for eyes.

101. *Po'n·xo-bodek*, instead of *po'n·xo-bonḷek* (see § 112), *Po'n·xo* (to be bright, transparent), the base of the verb; *bon*. suffix of the verbal noun (see § 112); *bodek*, the accusative definite (see § 112). *Po'n·xo-bon* (something bright, transparent). *Añje-d-uol-pon·xo-bon* = eye-place, transparent = opening for the eyes.

102. *Ā'ñimeḷe* (see 28).

103. *A'ña* (mouth); *deuḷe* (see 13).

104. *Āi* (also). See § 118.

105. *Ā-ñam.* See 79.

106. *Ti'ne*, adverb of time (see § 118).

107. *Cori'len·* (to be embroidered), base of the intransitive verb; *ul'*, suffix of the verbal noun, used as modifier (see §§ 82, 84).

108. *Ma'gideuḷe.* See 87.

109. *Pu'de* (in the yard, outside, or above, over, upon); see 29; *degen*, the vialis with the possessive element (see § 17).

110. *Yero'ye* (one-year-old reindeer fawn); *xar* (skin); *ma'giḷ* (jacket); *e*, suffix of the accusative.

111. *Moruc'e* (dress, put on); *ñam* (see 16).

112. *Ta'bun* (see 12).

113. *Pu'dedegen.* See 109.

114. *No'ji-n·er-e* = *no'ji* (soft reindeer leather); *n·er* (clothes); *e*, suffix of the accusative indefinite (see § 12).

115. *Yodu'tai* (wrap); *ñam* (see 16).

116. *Ta'čile* (afterwards), adverb of time (see § 118).

117. *Modo'to-ñam.* *Mo'do* (to sit), intransitive verb; *to* = *te*, suffix turning intransitive verbs into transitive; *modo'-to* (to seat, to place); *ñam.* See 16.

118. *O'rje* (in the middle), adverb of place (see § 119). They call thus the place of honor in their house; that is, the side facing the entrance.

119. *Modo'toñam.* See 117.

120. *Omo'če-bon* (something good), verbal noun (see § 112, *Omo'če* see 56).

121. *Le'ññide*, from *le'u* (to eat), base of the transitive verb; and *ñide*, conditional mode (see § 87).

122. *Ločil'* (fire); *ge*, the locative (see § 12).

123. *Pe'de-te-ñam.* *Pe'de* (to burn), base of the intransitive verb; *te* changes the verb into a transitive verb (to singe), see 117; *ñam.* See 16.

124. *Pu'dedegen.* See 109. It is equivalent to "over it" (the fire).

125. *Tabu'ngele* (it; that is, the idol). See 59.

126. *Tā.* See 84.

127. *Mo'i-nunu-ñam.* *Moi* (hold, keep), base of the transitive verb; *nunu*, suffix of the intensive-iterative (see § 104); *ñam.* See 16.

128. *Ta'ñde.* See 39.

129. *Me-legi'te-ñam.* *Me*, see § 107; *legi'te* (to feed), from the transitive verb *le'u* (to eat); *ñam*, see 16.

130. *Ka'cnei* (every), from the Russian *ka'shd'y.* To use the Yukaghir expression, it should be *le'ñde-o'nmun* (see § 57), instead of *ka'cnei le'ñdelge.*

131. *Le'ñdel-ge.* *Le'ñde* (to eat, in general), intransitive verb, formed from the transitive verb *le'u* (eat) by means of the suffix *de* (see § ñ); *l'* is the suffix of the verbal noun (see §§ 82, 83); *ge*, the locative (see § 12).

132. *Tāt.* See 23.

133. *Ā'-ñam.* See 79.

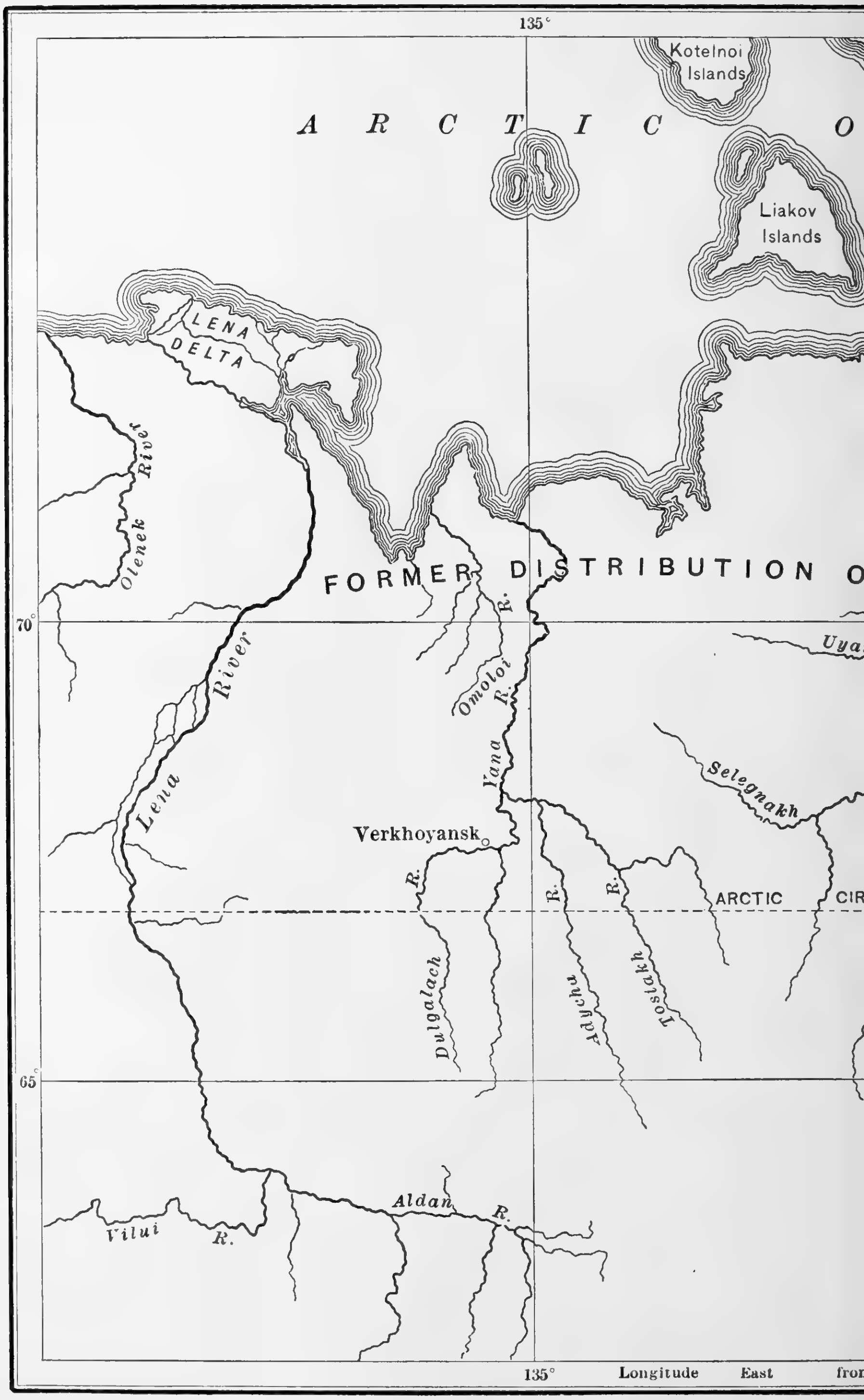
134. *Tabu'de.* See 73 and 75.

135. *Xo'in·eñi.* See 75.

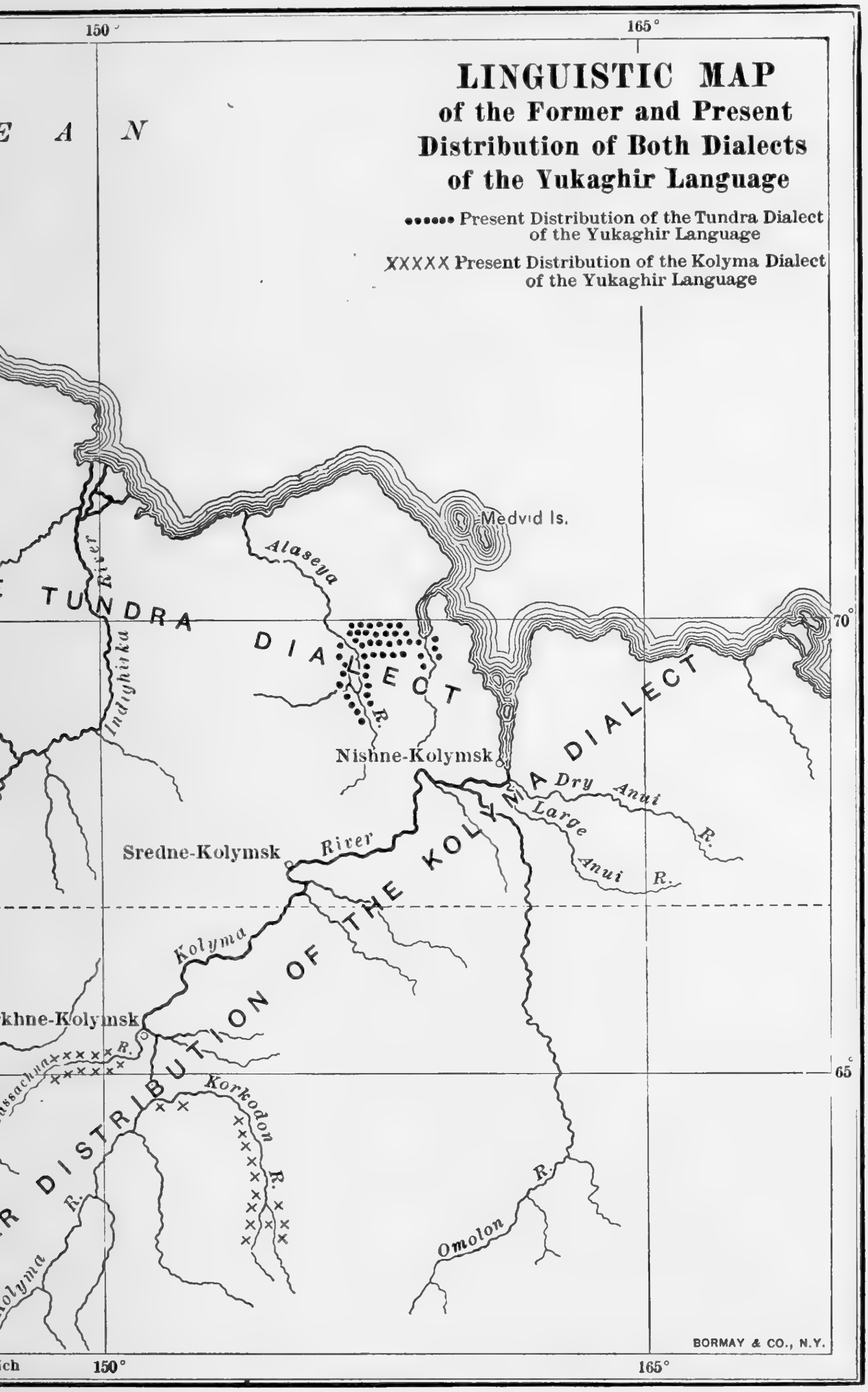
PLATE IV.

PLATE IV.

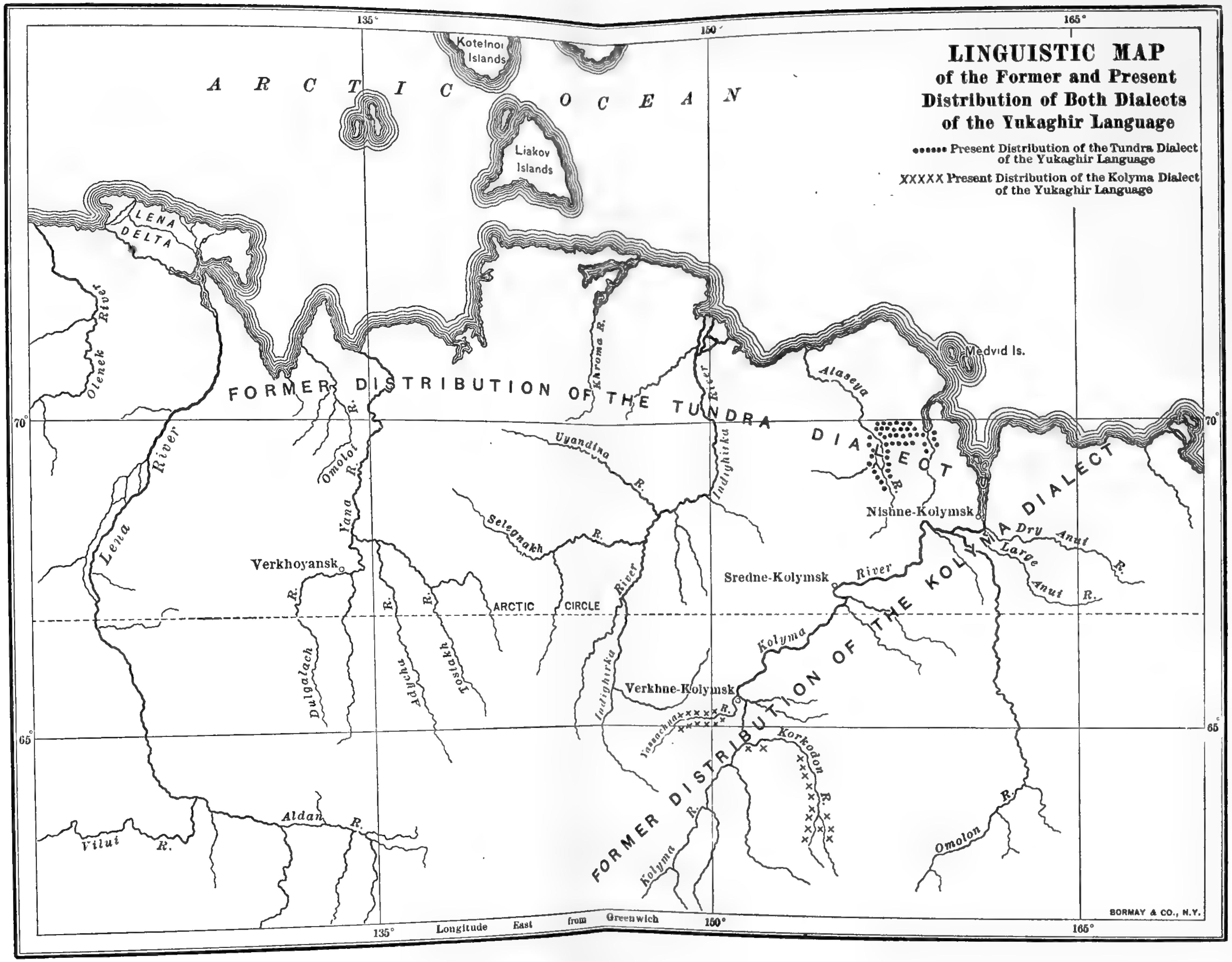
Linguistic map of the former and present distribution of both dialects of the Yukaghir language.



135°
Kotelnoi Islands
A R C T I C O
Liakov Islands
LENA DELTA
Olenek River
FORMER DISTRIBUTION O
70°
Lena River
R.
Omoloi R.
Uya
Yana
Selegnakh
Verkhoyansk
R.
R.
R.
ARCTIC
CIR
Dulgalach
Adycha
Tostakh
65°
Aldan R.
Vilui R.
135°
Longitude East fron



150°
165°
LINGUISTIC MAP
of the Former and Present
Distribution of Both Dialects
of the Yukaghir Language
•••••• Present Distribution of the Tundra Dialect of the Yukaghir Language
XXXXX Present Distribution of the Kolyma Dialect of the Yukaghir Language
E A N
Medvid Is.
Alaseya
River
TUNDRA DIALECT
Indighirka
R.
70°
Nishne-Kolymsk
KOLYMA DIALECT
Dry Anui R.
Large Anui R.
Sredne-Kolymsk
River
OF THE
Kolyma
khne-Kolymsk
R.
Korkodon R.
DISTRIBUTION
R.
Kolyma
65°
Omolon R.
BORMAY & CO., N.Y.
ich
150°
165°


LINGUISTIC MAP
of the Former and Present
Distribution of Both Dialects
of the Yukaghir Language
Present Distribution of the Tundra Dialect of the Yukaghir Language
XXXXX Present Distribution of the Kolyma Dialect of the Yukaghir Language
ARCTIC OCEAN
Kotelnoi Islands
Liakov Islands
LENA DELTA
Medvid Is.
FORMER DISTRIBUTION OF THE TUNDRA DIALECT
FORMER DISTRIBUTION OF THE KOLYMA DIALECT
Olenek River
Lena River
Omolot R.
Yana R.
Karoma R.
Indighirka River
Alaseya R.
Uyandina R.
Selegnakh R.
Verkhoyansk
Nishne-Kolymsk
Sredne-Kolymsk
Verkhne-Kolymsk
Kolyma River
Dry Anui R.
Large Anui R.
Dulgalach R.
Adychu R.
Tostakh R.
ARCTIC CIRCLE
Yassachna R.
Korkodon R.
Omolon R.
Aldan R.
Vilui R.
135°
150°
165°
70°
65°
Longitude East from Greenwich
BORMAY & CO., N.Y.

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MATERIALS FOR THE PHYSICAL ANTHROPOLOGY OF THE EASTERN EUROPEAN JEWS.

BY MAURICE FISHBERG.

CHAPTER I.[1]

INTRODUCTION.

The study of the somatic characteristics of the Jews has received the attention of many anthropologists in Europe. It was suggested that because they have kept themselves socially isolated for nearly two-thousand years, and have refrained from intermarriage with other races, the Jews offer a promising field for the solution of many obscure problems in the study of man. Considering that they have been scattered over almost every part of the habitable globe; by involuntary and mostly forced, migrations from city to city, country to country and from continent to continent, have been subjected to frequent changes in their physical environment, it was expected that a thorough study of their racial characteristics, may contribute to our meager knowledge of the influence of environment upon race. If the Jews, have really maintained themselves for the last four thousand years in absolute purity, the effects of climate, altitude, nourishment, economic and social conditions, should be ascertainable by a study of their physical organization. If on the other hand, they have intermarried with the races among whom

[1] The difficulties encountered while attempting to reach people willing to submit to anthropometric measurements are well known to every one who studied physical anthropology on the living. I therefore gratefully acknowledge the valuable assistance rendered me by Lee K. Frankel, Ph.D., Manager of the United Hebrew Charities of New York City, by affording me the opportunity to obtain anthropometric measurements in connection with my work as medical examiner to the Charities. Without Dr. Frankel's assistance this work could not have been done. I am also under obligations to Prof. Franz Boas for his valuable advice and suggestions during the preparation of the work. To Mr. Joseph Jacobs I am sincerely indebted for reading and revising the manuscript and proofs.

they have dwelt, or if extensive conversions to Judaism have taken place, and the modern Jews are thus a mixture of various racial elements, blended together in a more or less homogeneous group of people, they should offer excellent material for the study of the effects of racial intermixture on the physical organization of man.

There are very few anthropological data on the somatology of *pure* races. In fact we do not know of any *absolutely* pure races in existence. Migration, war and conquest have always been at work amalgamating various racial elements. But there are also very few data upon the effects of racial intermixture. The present writer is only acquainted with the investigations of Professor Franz Boas of the American half-breeds [1] and Mainoft's work on the intermixture of Russians with Yakouts.[2] Both of these investigations have conclusively shown that the tape and calipers may be of great service in the search for the origin of certain physical traits. If conversions to Judaism, open or clandestine intermarriage between Jews and non-Jews have taken place, it is of scientific interest to ascertain if possible, the effects of such intermarriage on the physical characteristics of the modern Jews.

The Racial Purity of The Jews.

Up to recent time two diametrically opposed views were held by anthropologists on the question of the purity of the Jewish race. Some have maintained that the Jews have preserved themselves in there original purity for the last four thousand years,[3] Richard Andree points out that the racial types represented on the ancient Assyrian and Egyptian monuments prove beyond doubt the constancy of the Jewish type. A look at the Jews painted on these monuments makes one believe that he sees the typical Jew of to-day. "No other race but the Jews," says Andree, "can be traced with such certainty backward for

[1] "Zur Anthropologie der nordamerikanischen Indianer," *Verhandl. der Berliner Anthropologischen Geselschaft*, 1895, pp. 367–411.

[2] I. I. Mainoff, "Pomes russkikh s yakutami," *Russian Anthropol. Journal*, 1900, No. 4, pp. 37–57.

[3] Milne Edwards, Prichard, Nott and Gliddon and others.

thousands of years, and no other race displays such a constancy of form, none resisted to such an extent the effects of time, as the Jews. Even when he adapts the language, dress, habits and customs of the peoples among whom he lives, he still remains everywhere the same. All he adapts is but a cloak, under which the eternal Hebrew survives; he is the same in his facial features, in the structure of his body, his temperament, his character."[1] Joseph Jacobs, who studied the question both from the anthropological and the historical standpoint is "inclined to support the long standing belief in the substantial purity of the Jewish race, and to hold that the vast majority of contemporary Jews are the lineal descendants of the diaspora of the Roman empire."[2]

This view was materially changed during the last thirty years after anthropological investigations of several thousand Jews by modern methods have been published. It is the prevailing opinion at the present that the Jews have not maintained their racial purity to the extent indicated by the authors just quoted. All, even those who speak of the subject from a sentimental standpoint, agree that there are two types of Jews, who are said to present physically distinct characteristics. They are the *Ashkenazim*, or German, Russian and Polish Jews, and the *Sephardim*, the Spanish and Portuguese Jews.[3] Vogt, in his

[1] Richard Andree, "Zur Volkskunde der Juden," Leipsig, 1881, pp. 24–25.

[2] Joseph Jacobs, "On the Racial Characteristics of Modern Jews," *Journal Anthropol. Institute*, XV, 1885, p. 53.

[3] The European Jews are divided into two main groups, *Ashkenazim* and *Sephardim*. The former constitute about ninety percent of the modern Jews, while the latter are only about ten percent. *Ashkenazim* has its origin in *Ashkenaz*, the son of Gomer, grandson of Japhet, and great-grandson of Noah (Gen. X, 3; I Chron. I, 6.). The Talmud and also mediæval rabbinical literature identify Ashkenaz with Germany and Teutons, while according to Saadia, the Slavs are meant (Jewish Encyclopedia, Vol. II, pp. 191–193). At present all the Jews from Germany, Poland, Russia, and Austria are called Ashkenazim partly because of the "Yiddish" or German jargon which most of them employ. The name *Sephardi* has its origin in *Sepharad*, the Biblical name of an unknown land into which the Jews exiled from Jerusalem were brought (see *Abadias*, 20). The mediæval rabbis believed that Sepharad referred to Spain and Portugal; hence the name Sephardim for the Spanish Jews. When banished from Spain in 1492, about 300,000 Jews were dispersed; some wandered to northern Africa, others to Italy, England, Holland, Turkey, Asia Minor, etc. The remnants of these Jews living at the present

"Lectures on Man" gave an excellent description of these two types. "The first found mostly in Northern Russia and Poland, Germany and Bohemia are often characterized by red hair, short beard, short concave nose, small grey lustrous eyes; their body is inclined to be stout, the face round with broad cheek-bones, is similar to some of the northern Slavonians. On the other hand in the Orient, and around the Mediterranean, and also in Portugal and Holland are found Jews with long black hair and beard, large almond shaped black eyes, a melancholy cast of countenance, with a long face and a prominent nose. In short the type which we find represented in the paintings of Rembrandt."[1] This view was supported by Broca, who stated that in his opinion the Jews are not a pure race, but a mixture of various races. The blond Jews in Alsace-Lorraine and Germany have their origin in intermixture with northern races; in Russia there are evidences of mixture of Jews with Slavonians, Finns and Tartars. The view that there are two racial types of Jews has been shared by many other anthropologists; Stieda, who was the first to investigate the problem in Russia by directing two of his pupils to obtain measurements of Jews in Russia, arrived at the same conclusion which is shared by Topinard, Deniker, and Weisbach.[2] Maurer describes in detail the physical traits of two races of Jews living in Bosnia: One, the Turanian type, with prominent cheek bones, with a broad mouth

time in the Bakan States, as Bosnia, Europeon Turkey, Roumania, etc., are also known by the name *Spagnuoli*, probably because of the Spanish jargon they still employ. There were many of them in the United States, but they are rapidly disappearing by intermarriage wilh Ashkenazim, etc. These two groups of Jews differ in their traditions, rites, and physical type. The Separdim consider themselves as the branch of Israel which has maintained itself to the present day in its original Semitic purity, and kept itself free from admixture of non-Semitic blood than the Ashkenazim. They refuse to intermarry with the German Jews, have their own synagogues, cemeteries, etc.

[1] Karl Vogt, Vorlesungen über den Menschen, II, p. 238.

[2] See L. Stieda, "Ein Beitrag zur Anthropologie der Juden," *Archiv für Anthropologie*, XIV, pp. 61–71, 1883; B. Blechman, "Ein Beitrag zur Anthropolder Juden," Dorpat, 1882, Diss.; P. Topinard, "Eléments d'anthropologie générale," Paris, 1886; J. Deniker, "The Races of Men," London, 1900; A. Weisbach, "Körpermessungen verschiedener Menschenrassen," *Zeitschrift für Ethnologie*, Erganzunsband, 1877.

having thin lips; and large jaws. The nose is pear shaped, narrow and depressed at the root. The head is round, the eyes blue, and blond or reddish hair are frequently encountered among them. The other type is said to be possessed of all the traits which characterize the Semites, such as long head, dark hair and eyes, etc.[1]

Other anthropologists have seen in the Jews more than a mixture of two races. C. Ikof, basing his opinion on measurements obtained of 120 Jews in Russia, and 55 Jewish and Karaite skulls derived from Russia, Turkey, Italy, Caucasia, etc., concludes that only the Jews of the Orient and in Southern Europe (Balkan states, Spain, Italy, Algiers, Morocco, Tunis, etc.), are of Semitic origin, with only a slight intermixture of other racial elements. The Jews in western Europe are possessed of all the morphological evidences of a strong mixture of Semitic blood with the indigenous populations of these countries. But the Jews in Russia are not Semites at all, because physically they have nothing in common with the latter, and actually belong to an entirely different race.[2] Many others have spoken of the Jews in a similar manner. Lagneau, for instance, denies that there are any Jews of pure race in any part of the world. The German, Polish and Russian Jews are a mixture of Teutons, Slavonians and Cossacks. The Jews on the north coast of the Mediterranean are mostly proselytes to Judaism of Hellenic and Latin origin; and the Jews in North Africa are the result of the intermixture of the Jews who originally resided here in antiquity in Egypt and Carthaginia with the local tribes of Berbers, Kopts and Phœnicians, later also with the Greek and Roman elements, finally during the middle ages with the Arabians.[3] Weissenberg also, after an investigation of the physical characteristics of the Jews in South Russia, denies the prevailing idea that there is a unity of the Jewish type. He distinguishes the "fine," the

[1] Franz Maurer, "Mittheilungen aus Bosnien, Das Ausland, 1869, p. 1163.

[2] K. N. Ikof, "Neue Beiträge zur Anthropologie der Juden," *Archiv für Anthropologie*, XV, 1884, pp. 369–389.

[3] G. Lagneau, "Sur la race juive et sa pathologie," *Bull. de la société d'anthropologie de Paris*, 1891.

"coarse" Jewish type and also North European, the Caucasian, Mongolian and other types among them. [1]

It is thus seen that most of the modern anthropologists who have studied the physical characteristics of the Jews have strongly discredited the theory of the racial purity of the Jews. Renan aptly said "il n'y pas un type juif, il y a des types juifs," and "judaisme est une religion, mais n'est pas un fait ethnologique, mais une type accidentel." [2] Professor Ripley, after a most thorough study of the literature on the subject, arrives at the same conclusion.[3]

Physical Anthropology of the Jews.

At the present there are no scientific writers on the subject who claim that the Jews are the direct descendants of Shem, the son of Noah, and that during the last 4,000 years have not admitted any non-Jewish blood into their veins through intermarriage or conversions to Judaism. Even the sanguine defenders of the racial purity of the Jews, as Andree, Jacobs and Judt, agree that, in their early history, the ancient Hebrews have intermarried with the various indigenous tribes of Egypt, Syria and Palestine, and later during the diaspora with the Romans and Greeks. Biblical tradition and history abounds in evidence to this effect. But not all agree on the question whether the Jews have ethnically intermarried with European races during the last 2,000 years of their dispersion. Some of the authors cited above bring forth evidence in support of this theory, while others deny its significance. From the present state of physical anthropology it is to be expected that if these intermarriages have really taken place to any extent the modern Jews should be possessed of many or most of the morphological traits which characterize their Gentile neighbors. This can be ascertained by a study of the anthropology of the Jews, in the same manner as Professor Boas has studied the American Indian half-breeds, and Mainoff, the Yakout half-breeds in Russia.

[1] S. Weissenberg, "Die südrussischen Juden," *Archiv für Anthropol.*, XXIII, 1895.

[2] E. Renan, "Le Judaisme comme race et comme religion," Paris, 1883.

[3] Wm. Z. Ripley, The Races of Europe, New York, 1899. Chapter XIV.

In part such work has already been done. Professor Virchow's investigations of the color of the skin, hair and eyes of the school children in Germany; Schimmer's work in the same line in Austria, Körösi in Hungary, Mayr in Bavaria, and Wateff's in Bulgaria, have comprised nearly 150,000 Jewish children, compared with non-Jewish children in the various provinces in the named countries. Here we find that the percentage of blondes among the Jews is quite large, 32 percent in Germany, 27 in Austria, 23 in Hungary, 22 in Bulgaria, etc. The percentage of light eyes is also large as can be seen from the appended table (Table I). The type of pigmentation of the Jews being dark, one is at once struck with the large percentage of Jews having light hair and fair eyes combined, and the origin of of these "Indogermanic" Jews (as Virchow speaks of them) is at once questioned.

TABLE I.[1]

COLOR OF HAIR AND EYES IN 148,208 JEWISH CHILDREN.

Country.	No. of Children.	Hair (Percent).				Eyes (Percent).			Authority.
		Blond.	Brown.	Black.	Red.	Blue.	Brown.	Gray.	
Germany	75,377	32.03	54.39	11.46	0.4	19.30	51.99	27.00	Virchow.
Austria	59,808	27.0	55.40	16.90	0.6	23.50	45.90	30.60	Schimmer.
Bavaria	7,054	30.0	50.00	20.00	—	20.00	49.00	31.00	Mayr.
Hungary	3,141	23.7	57.00	19.30	—	18.30	57.50	24.20	Körösi.
Bulgaria	2,828	22.35	59.59	18.06	2.58	19.38	61.34	22.13	Wateff.

It is a striking fact, however, that a study of the distribution of the blond Jews according to the provinces of these countries

[1] The figures in this table are taken from: R. Virchow, "Gesamtbericht über die Farbe der Haut, der Haare, und der Augen der Schulkinder in Deutschland," *Archiv für Anthropologie*, XVI, 1886; G. A. Schimmer, "Erhebungen über die Farbe der Augen, der Haare und der Haut, bei den Schulkindern Oestreichs" *Mitt. der Anthropol. Gesel. Wien*, Suppl. I, 1884; G. Mayr, "Die Bayerische Jugend nach der Farbe der Augen, der Haare und der Haut," *Zeitschrift des Konigl. bayerischen statistisch. Bureau*, VII, 1875, pp. 273–311; J. Körösi, Couleur de la peau, des cheveux et des yeus à Budapest," *Ann. de Demographie*, 1878, pp. 136–137; S. Wateff, "Anthropologische Beobachtungen der Farbe, der Augen, der Haare und der Haut bei den Schulkindern von den Türken, Pomaken Tataren, Armenier, Griechen und Juden in Bulgarien," *Correspondenz Blatt der deutschen Ges. für Anthropol., Ethnol. und Urgeschichte*, XXXIV, 1903.

does not indicate the origin of the fair Jews, and does not confirm the opinion that their blondness has been acquired in the countries where we find them at the present day. For it is not found that the percentage of blond Jews is larger in the northern provinces of Germany, where the indigenous population shows the highest proportion of blonds; on the contrary, here they are in the least, but further east and south, in Galicia, Bukowina, etc., where the indigenous population is darker, the Jews show the highest percentage of blonds. This fact brought out in Virchow's work has given rise to considerable discussion. Many (Luschan, Andree, Judt, Elkind) are inclined to believe that these blond Jews are the descendants of the fair-haired individuals among the ancient Hebrews. Andree and Prunner Bey point to the modern non-Jewish Syrians, among whom fair hair and eyes are not infrequent. Luschan says that many blonds inhabited Syria and Palestine in antiquity; they were known in the Bible as the Amorites, "the sons of Anak," who were "men of great stature," and are considered to have been "Aryans." The modern blond Jews are said to be the descendants of the Amorites, with whom the ancient Hebrews intermarried quite freely.[1]

In Galicia, Majer and Kopernicki have studied the comparative anthropology of the races in that country, including the Poles, the Ruthenians and the Jews. The results they have obtained show great similarities in the somatic characteristics of these three races. Their stature is about the same, Jews, 162.3 cm., Poles, 162.2, and Ruthenians, 164. The cephalic index is: Jews, 83.5, Poles, 84.4 and Ruthenians, 83.3. In the same manner, while the Jews are much darker than the other still 13.7 percent have fair hair and 29 percent fair eyes.[2] In Russia Talko-Hryncewicz has compared the Jews with the Little Russia Leto-Lithuanians, and White Russians. He found that in Little Russia where the population is characterized by

[1] F. v. Luschan, "Die anthropologische Stellung der Juden," *Correspondenz Blatt der Deutsch. Gesel. für Anthropol.*, XXIII, 1892, pp., 92–102.

[2] J. Majer and J. Kopernicki, "Chrakterystyka fiziczna ludnosci galicijskiej," *Zbior viadom. do anthropologii krajovej, Krakow*, I, 1877, IX, 1885.

tall stature, the Jews are also taller than in Lithuania. That the stature of the Jews depends on the stature of the Gentiles of the country they inhabit has also been shown by Snigirew, who compiled the recruiting statistics of Russia for 1875. In Poland where the Poles are short of stature (162.7 cm.) the Jews measure only 161.3 cm. (4,470 observations); in Lithuania the general population averages 163.9 cm. and the Jews 161.2 (2,122 observations). In the Baltic provinces where the Gentiles are much taller the Jews are also taller, measuring 163.1 cm. on the average, and in Little Russia where the natives are about 167 cm. in height the Jews are 164.2 cm.[1] And in Odessa they are even taller, 166.5 cm.[2] In Western Europe the same has been observed. In Bavaria the average stature of the Jews is 162.0 cm.[3] while in Baden, where the general population is taller, the Jews measure 164.3 cm.[4] and in Turin, Italy, the Jews also measure 163.3 cm. on the average.[5]

The head-form of the Jews has confirmed this fact in a more striking manner. It is observed that the cephalic index corresponds to that of the races among which they live. In Caucasia, where many of the natives are hyperbrachycephalic, the Jews are also extremely round-headed, and in Eastern Europe where most of the native races are mesocephalic, the Jews are the same, and in north Africa, where dolichocephaly is prevalent we find the Jews with the same head-form. This is best shown in the accompanying table (II) from which the following striking fact is to be noted: The Poles in Galicia are brachycephalic, cephalic index 84.4, and the Jews here have an average index of 83.6; in Poland the Poles have an average index of only 80.85, and the Jews also only 81.89.

[1] Snigirew, "Materiali dlia medizinskoi statistiki i geografii Rossii," *Voenno-medizinski zhurnal*, 1878, 1879.

[2] I. I. Pantukhof, "O virozhdayushchikhsia tipakh semitow," *Proc. Russian Anthropol. Soc. at St. Petersburg*, 1889.

[3] J. Ranke, "Zur Statistik und Physiologie der Körpergrösse der bayerischen Militärpflichtigen, etc.," *Beiträge zur Anthropologie und urgeschichte Bayerns*, IV, 1881, pp. 8–35.

[4] Otto Ammon, "Zur Anthropologie der Badener," Jena, 1899, p. 646.

[5] C. Lombroso, "L'antisemitismo e le scienze moderne," Torino, 1894, appendix.

Table II.

Cephalic Index of Jews and Non-Jews in Various Countries.

Jews.		
Country.	Cephalic Index.	Observer.
Caucasus	87.5	Pantukhof.
Galicia	83.6	Majer and Kopernicki.
Baden	83.5	Ammon.
Little Russia	82.9	Talko-Hryncewicz.
Turin, Italy	82.4	Lombroso.
Lithuania	81.7	Talko-Hryncewicz.
Russian Poland	81.89	Elkind.
White Russia	80.9	Yakowenko.
Non-Jews.		
Race.	**Cephalic Index.**	**Observer.**
Aïssors in Caucasia	87.89	Arutinoff, Pantukhof.
Armenians in Caucasia	87.0	Ivanowski.
Poles in Galicia	84.4	Majer and Kopernicki.
Ruthenians in Galicia	84.3	Majer and Kopernicki.
Germans in Baden	84.14	Ammon.
Russians, Little	83.2	Talko-Hryncewicz.
Italians in Turin	84.9	Lombroso.
Letto-Lithuanians	80.60	Talko-Hryncewicz.
White Russians	83.2	Talko-Hryncewicz.
Poles in Russia	80.85	Elkind.
White Russians	81.87	Ivanowski.

In Baden the cephalic index of the Germans is 84.14 and of the Jews 83.5, and it is remarkable, says Ammon, that in the parts of the country where the heads of the indigenous population are broader, those of the Jews are about the same, and the reverse. There are very scanty data about the cranial form of the Jews living among extremely dolichocephalic races, particularly Semites, as the Arabians, Syrians, Berbers, etc., but all the evidence available goes to prove that here they are also dolichocephalic. Thus, Pruner Bey brings measurements of three Jewish skulls from north Africa, with a cranial index of 75, and two Jewesses with an index of 77.[1] Quatrefages and Hamy have measurements of a Jew from Algiers with a cephalic index of 74.44, and five from Holland, 72.2,[2] and Dessau five

[1] *Memoirs de la société d'anthropologie, de Paris,* Tome II, fasc. 4, 1864, p. 417)

[2] "Crania Ethnica," Paris, 1882, p. 513.

other skulls from Holland (in Musee Vrolic) with an average index of 77.48. Davis described the skulls of three Italian and two Dutch Jews with an index of 76.33.[1] All these skulls, confirm that the Jews who live among dolichocephalic races are also dolichocephalic. The crania from Italian and Dutch Jews mentioned by Dessau, Davis and Quatrefages are of Spanish Jewish origin, and their dolichocephaly corresponds to the type of head of the indigenous population of Spain.

It is a fact worthy of mention that the Jews expelled from Spain in 1492, known as "*Sephardim*," or *Spagnuoli* have not everywhere preserved their type as is generally supposed. Thus measurements taken by Jacobs on 50 Sephardim in London show that the proportion of dolichocephalic heads (cephalic index less than 78) among them was 17 percent, as against 28.3 percent among the *Ashkenazim*.[2] In Turin also the cephalic index of the Jews is 82.14 and only 22.32 percent had indices less than 80.[3] This is confirmed by Livi who found the average index in Italian Jews to be 81.6.[4] In Bosnia Glück obtained measurements of 55 Spangnuoli, whose cephalic index was 80.1, and only 7.3 percent were dolichocephalic.[5] From all these measurements it is evident that the modern Sephardim are not long headed as was supposed. It is doubtful whether this is due to intermarriage with Ashkenazim, because the former have kept themselves separated from the latter. The frequency of blond and red hair among these Jews is also almost as large as among the German Jews. Beddoe found three percent of blonds among the Sephardim in Constantinople and Bruza, and six percent in London.[6] In Turin Lombroso found 5.8 percent, and Livi even 14.7 percent as against only 9.3 percent among the general population of Italy, and in Bosnia even 18.2 percent

[1] J. B. Davis, "Thesaurus craniorum," London, 1867.

[2] Joseph Jacobs, "On the comparative anthropometry of English Jews," *Journ. Anthropol. Institute*, XV, pp. 76–88.

[3] Lombroso, *loc. cit.*

[4] R. Livi, "Antropometria militare," Roma, 1896, pp. 188–190.

[5] L. Glück, "Beiträge zur physischen Anthropologie der Spaniolen," *Wissenschaftliche Mitteilungen aus Bosnien und der Hercegovina*, IV, 1896, pp. 587–592.

[6] J. Beddoe, "On the physical characters of the Jews," *Transactions of the Ethnol. Soc. London*, I, 1861, pp. 222–237.

of fair hair and 30.9 percent of fair eyes,[1] while Jacobs found 21.3 percent of the Sephardim in London had blue eyes, which is more than among the Ashkenazim in that city who had only 11.1 percent of fair eyed.

All these data tend to show that there is a great diversity of types of Jews when their stature and craniology is considered; but when looked at from the standpoint of pigmentation, they present a more or less uniform type — wherever data are obtainable it is found that about ten to fifteen percent have fair hair, and over thirty percent fair eyes. In other words, morphological characters which are obtained by the use of the tape and calipers, and which are not influenced to an appreciable extent by the personal equation of the observer depend in the Jews on the same characters peculiar to their non-Jewish neighbors, among whom they have lived for centuries. On the other hand pigmentation, a trait the study of which is subject to the personal equation of the observer (what one living among brunettes will call blond, may be called by another observer, living among blonds, a brunette) is found uniformly frequent among the Jews in various countries, independent of the frequency in which it is found among the Gentiles among whom they have lived.

It appeared to the present writer that an anthropological study of the Jews in various countries by one observer, thus greatly eliminating the effects of the personal equation, may contribute to the solution of some of the obscure problems of the origin of certain physical traits of the Jews. It would be quite difficult for one individual to make such an investigation in Europe. Besides the extensive traveling it would entail, it would also be a difficult task to meet with Jews willing to submit to anthropometrical measurements. One has to read Dybowsky's experiences in Minsk, Russia, to be convinced that in eastern Europe the task would prove quite difficult. After paying an agent for procuring individuals willing to submit to measurements for a consideration, it so happened that one of the Jews measured died suddenly. This caused an alarm all over the city, the local police

[1] Glück, *loc. cit.*

interfered, and the measurements had to be discontinued. Most of the other anthropological researches of Jews in eastern Europe were obtained by physicians, in the regular course of their practice among these people, or in hospitals. Very little success can be expected from trying to induce these people to submit to measurements for scientific purposes.

New York City is the best place in the world to obtain anthropometrical measurements of Jews. Of the 600,000 Jews or more living here, more than three quarters have arrived to the United States within the last thirty years from the various European countries, also from Asia and even Africa. The vast majority are natives, or the descendants of Jews from Russia, Poland, Austria, Hungary, Roumania and other parts of eastern Europe; some have come from Syria, Palestine, and even from Algiers, Tunis and Morocco. The material for investigation is consequently the most heterogeneous, and can not be found to such an extent in any other city or even country. By using ordinary tact I succeeded to obtain measurements of over 2,000 individuals of both sexes, and all over twenty years of age. Over one half of these were applicants for relief in the United Hebrew Charities in this city. They offered no serious objections to the procedure, believing that the measurements are a means of discovering the nature of their ailment, or their physical ability to work. Only the native Jews objected seriously, suspecting that these measurements are the "Bertillon system," and denying guilt of any crime, they usually refused to submit. It is to be regretted that mainly for this reason I succeeded to obtain measurements of only 124 Jews natives of the United States.

The following data were obtained for each individual: (1) Age; (2) sex; (3) nativity, country and province; (4) how long in the United States, if foreign born; (5) occupation; (6) color of — (*a*) the hair, (*b*) the eyes, (*c*) beard, (*d*) variety of the hair; (7) stature; (8) girth of the chest, during quiet respiration; (9) longest diameter of the head; (9) width of the head; (10) cephalic index; (11) circumference of the head; (12) height of the nose; (13) width of the nose; (14) nasal index; (15) height of the face; (16) width of the face; (17) facial index.

Each of these data was recorded on a specially prepared card for each individual, which made it afterwards easy to classify, and compute the figures in various groups.

Method of Investigation of the American Jews.

The main aim of this investigation has been to gather materials for a comparison of the somatic characters of the Jews within the races and peoples among which they have lived before they have emigrated to the United States. The nativity of the Jews under consideration has therefore been considered not by geographical or political boundaries, but as far as was possible to ascertain, by ethnic conditions of their native countries. When one stated that his nativity was Russia, he was also asked in which province (government) of the empire he was born. As is well known, 93.9 percent of the 5,189,400[1] Jews in Russia, live in what is known as the "Pale of Settlement." This comprises 25 provinces in western and southern Russia, and Poland. The indigenous population of this region consists mainly as follows; In Poland the Poles; in western Russia we have the White-Russians in the provinces of Minsk, Mohileff and Witebsk; and the Letts and Lithuanians in the provinces of Wilna, Kovno and Grodno; the Little-Russians in Vohlin, Kieff, Podolia, Poltava, Tchernigoff, Bessarabia, Cherson, etc. It must however be remembered that while the predominating ethnic elements in these provinces are as indicated, still in many parts ethnic conditions are not so simple. Some parts of Russian Poland have a large population of White-Russians and Lithuanians and the reverse; In south and southwest the majority of the natives are Little-Russians, but in Bessarabia, parts of Podolia, etc., a fair number of Wallachians, Roumanians, etc. are encountered and further south, many Tartars. To obviate as far as possible all these disturbing factors, and to make the best of the situation, it was considered best to divide the Russian Jews into three groups: (1) *Polish Jews*, from the ten Polish provinces; (2) *Lithuanian and White-Russian Jews*, from Kovno,

[1] Census of Russia, 1897.

Vilna, Grodno, Mohileff, Minsk, Witebsk, etc.; (3) *Little-Russian Jews*, from Vohlin, Kief, Podolia, Poltava, Tchernigoff, Bessarabia, Cherson, etc.

These were compared with the races among which they have lived in all cases where material for comparison was available in anthropological literature. The immigrant Jews from Galicia were compared with the Poles and Ruthenians in that country, and the Roumanian and Hungarian Jews, with the native Roumanians and Magyars in these countries. By dividing the material into groups according to nativity, it was found that the number of observations in each group is rather small, to give reliable results. The figures obtained by measurement of the immigrant Jews in New York, were then combined with figures obtained by measurement of Jews in eastern Europe. In this manner it was possible to present a larger number of observations, making the results and conclusions more reliable. Thus our own observations of Galician Jews include 305 men, but combined with 836 men reported by Majer and Kopernicki, we have 1,141 observations; the measurements on Polish Jews, of which 315 were measured in New York, were combined with 200 cases measured by Elkind in Warsaw, giving a total of 515 observations, etc. These combined figures were considered in connection with figures obtained by measurement of non-Jews in eastern Europe taken from the anthropological literature on these races. It was often deemed advisable to bring detailed statistics, because most of the literature referred to, is published in the Russian or Polish languages, which makes it inaccessible to the average American reader. For Galicia, Majer and Kopernicki's and Weisbach's works on the Poles and Ruthenians were used; for the Russian Poles Elkind's work was taken as standard, besides this, Olechnovicz, Talko-Hryncewicz, and Zakrzewski were often consulted. For the Little-Russians, Talko-Hryncewicz's work was principally used, and also Diebold, and Belodied. For the Lithuanians and White-Russians, Talko-Hryncewicz, and Eichholtz's researches, and the Roumanians, Pittard's, and the Hungarians, Weisbach's, and Janko's works. Besides these, Ivanowski's recent compilation

on the anthropology of the races in Russia, was freely drawn upon.

It was considered of importance to discuss some special problems in connection with the study of the physical anthropology of the immigrant Jews in the United States. First the question of selection by immigration was investigated. This was done by comparing the results obtained by the study of the immigrant Jews with those who were measured in their native land. Literature on the Jews in eastern Europe was available only for Poland, Galicia, Little-Russia, Lithuania, and White-Russia. It could not be obtained for the Hungarian and Roumanian Jews, the measurements here reported, as far as our knowledge goes, are the first published. In this connection particular attention was paid to the differences in respect to stature, head-form, pigmentation, between the immigrants and the stay-at-homes. Next to this, the effects of occupation and social conditions on stature was considered, for reasons which are fully set forth in the text.

The author is under the impression that he presents here, besides his own investigations on the anthropology of the Jews, also most of the available data on the subject published in European literature on the anthropology of the Jews and the races and peoples among whom they have lived for centuries. Analyzing the similarities and differences of the physical type of the Jews as compared with the Gentiles in the same country, it is to be expected that many points may be brought out which may contribute to the solution of some of the more important problems presented by this most peculiar of races.

CHAPTER II.

Stature.

The average stature of the 1,528 Jews examined by the present writer in New York City is 164.5 cm. (5 feet 4¾ inches). The maximum height is 187.5 and the minimum 135 cm. The tallest individual was thus 23 cm., or 13.97 percent, larger than the average; while the shortest individual was 29 cm., or 17.97 percent of the average stature. The variation is thus seen to be more active in the production of shortness of stature. As a whole, the range of extreme individual variation extended over 52 cm., or 31.61 percent of the average height, which is not large when compared with that observed in other European races, but quite large when considered in connection with observations on Jews in various European countries. Thus, from Blechman's work on the anthropology of the Jews in Russia, we find that the range of individual variation was only 17.4 percent of the average stature; Yakowenko found it to be, among the White-Russian Jews, 18.7 percent; Weissenberg in South Russia, 21.5 percent; Talko-Hryncewicz in Little-Russia, 23.4 percent. The only group of Jews in whom the extreme individual variation of stature exceeds that observed among the Jews in New York are the Galicians, reported by Majer and Kopernicki; they show a range of 34.5 percent of the average stature. Among other peoples the range of variation has been much larger; in Gould's extensive American statistics we find it to extend over 108 cm. But we deal here with a conglomeration of races. Pagliani, in Italy, has found a difference of 74 cm. between the maximum and minimum stature, and the same value has been found among conscripts in Baden, observed by Ammon, while the Jews in the same locality have shown a range of variation of stature of only 30 cm. — less than one half. Another fact worthy of note is that not one individual of 190 cm. in height or over was encountered among these 1,528 Jews

in New York, and a survey of the literature of the anthropology of the Jews does not reveal one recorded. According to Gould's statistics, nearly 5 individuals in 1,000 are taller than 190 cm., and in England, according to the report of the Anthropometric Committee, 3 in 1,000. This again accentuates the shortness of stature of the Jews when compared with a tall people like the Americans or the English. The Italians, who are of about the same stature, or even lower than the Jews, show the same characteristic. Pagliani found only one individual in 7,000 examined to be 190 cm. or over in height. That the shortest individual among the Jews observed in New York was 135 cm. is also peculiar — it is best explained by recalling that dwarfed persons are less likely to emigrate to a distand land, and perhaps also that the immigration authorities may not permit their landing.

Biologists have recently been making use of another method of estimating the variability of physical characteristics which gives better results than the mere average, with the calculation of the extreme variation of the maximum and minimum. It is known as the "error of mean square" or the "index of variability." This is determined as follows: At first the deviations [x] from the average, both positive and negative, are determined. Each of these is then squared [x^2] and then added, and the sum is divided by the number of observations [n], and finally the square root of the quotient is extracted, thus:

$$\sigma = \sqrt{\frac{\Sigma(x^2 \cdot f)}{n}}.$$

The resulting "σ" is termed by Pearson the "standard deviation." It is a concrete number, being expressed in the same units of measurement as the measurement of the individuals measured. In the case of human stature it is expressed in centimeters.

To make use of this method of estimating the variability of stature of the Jews, the magnitudes obtained by measurement were arranged in a series of classes, each class representing the number of persons who have attained a certain height, at inter-

vals of one centimeter. Thus twelve persons were observed in the class between 152 and 152.9 cm. in height; 62 in the class between 169 and 169.9 cm., etc. The average stature being 164.5 cm., it is seen that in the first case "x" = $-$ 12.5 cm.; "x^2" = 156.25 and "$x^2 \cdot f$" = 1875. In the second class "x" = + 4.5, "x^2" = 20.25, and "$x^2 \cdot f$" = 1,255.5. This was done for each deviation (grouped by centimeters), beginning with the smallest and ending with the largest value. The products of "$x^2 \cdot f$" were then added together and the sum of these divided by "n" = the number of individuals measured = 1,528, and the square root extracted from the quotient. By this process it was found that the standard deviation of 1,528 Jews was for their stature $\pm$ 6.58. Within the limits of $\pm$ 6.58 it is theoretically expected that about 68 percent of the number of variates should lie. Empirically this was confirmed. We found that within the limits of the standard deviation, *i. e.*, 164.5 + 6.58 (=171.08), and 164.5 $-$ 6.58 (=157.92) were 1027 individuals = 67.21 percent.

As is well known, the determination of the mean or average is never perfect, it is always only an approximation to the true average. This is due to inevitable errors of observation and calculation. These errors may be diminished by careful attention to details while taking measurements, and calculating the results, or by taking measurements on a very large number of people, but they can never be entirely eliminated. The finding of the "*probable error*" is a good method of determination of the accuracy of the average value. This is determined by multiplying the standard deviation by the constant 0.6745 and dividing the product by the square root of the number of individuals measured thus:

$$\pm 0.6745 \times \frac{\text{Standard Deviation}}{\sqrt{\text{number of observations}}} = \pm 0.6745 \frac{\sigma}{\sqrt{n}}.$$

The probable error gives the closeness of the approximation to truth. In the case of the Jews under consideration we have calculated that the probable error is 0.1133 cm. With the aid of this figure we can say that there is an even chance that the

true average lies within the limits of ± 0.1133; that the chances are four to one that the true average lies within twice these limits, and nineteen to one that it lies within thrice these limits. From the nature of the method used in obtaining the probable error, it will be observed that the probable error is less, *i. e.*, the average is more accurate, the greater the number of observa-

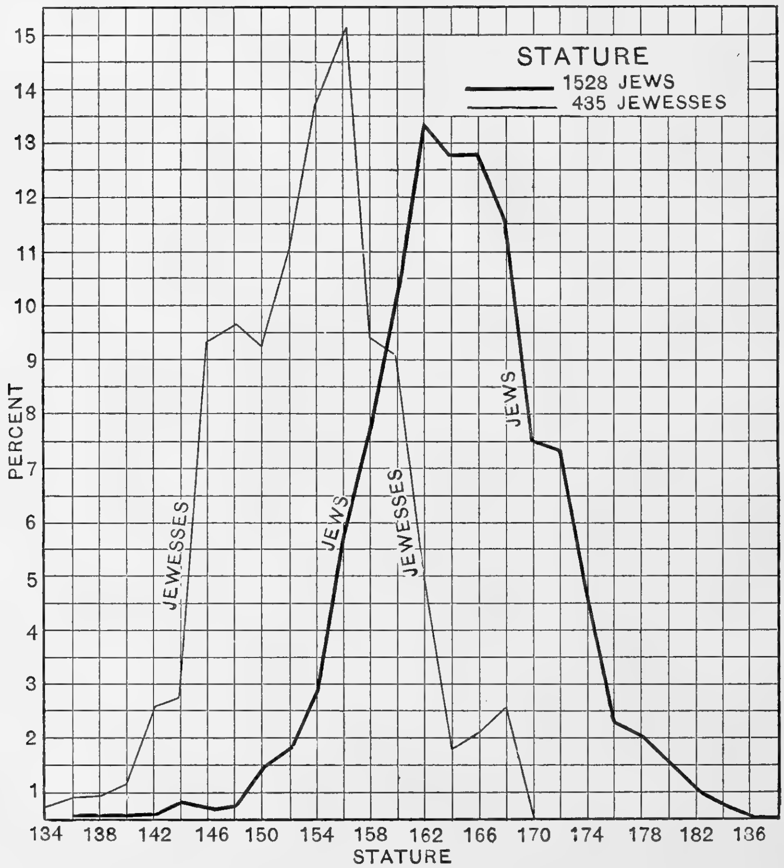

FIG. 1.

tions. This accuracy does not increase, however, in the same proportion as the number of persons measured, but as the square root of this number. As the standard deviation decreases, the probable error of the mean decreases.

As our study of the Jews is mainly concerned with their racial characteristics, if any such can be discerned, we can not rely on the average alone to determine the type. This is only a convenient, but very vague, means to express a complex group of

figures by a single or a few numbers. In order to appreciate, and bring out prominently, the various elements which compose a population we use other methods, besides the average. The best and the most widely adapted by anthropologists of the present day is that of coördination and seriation, by arranging the figures obtained from measurement of the individuals in an ascending or descending order of figures, each expressing a certain stature. Thus we may elicit one or more figures around which most of the individuals are grouped; various racial elements may in this manner be discerned in a group of people who apparently are of a single more or less pure race.

TABLE III.

STATURE OF 1,528 JEWS.

Stature (in cm.).	Number.	Percent.	Stature (in cm.).	Number.	Percent.
135–136	1	0.07	163–164	189	12.37
137–138	1	0.07	165–166	189	12.37
139–140	1	0.07	167–168	169	11.06
141–142	2	0.13	169–170	107	7.00
143–144	4	0.26	171–172	96	6.28
145–146	3	0.20	173–174	67	4.38
147–148	4	0.26	175–176	28	1.83
149–150	15	0.98	177–178	23	1.50
151–152	20	1.31	179–180	16	1.05
153–154	37	2.42	181–182	9	0.60
155–156	82	5.36	183–184	6	0.40
157–158	110	7.29	185–186	1	0.07
159–160	150	9.82	187–188	1	0.07
161–162	197	12.89	Total.	1,528	100.02

In Table III this has been done with the figures obtained by measuring the Jews in New York. It will be seen from the figures in this table that up to the height of 148 cm. are very few individuals; only one percent were observed to be of such low stature. The number of persons at a given height now begins to increase slowly until the height of 162–163 is reached. In this group we find the largest number of people — 197 or 12.89 percent. The proportion of observations now remains about stationary, till 166 cm. is reached when the percentage begins to decrease steadily until the height of 180 cm., where the number of persons is again becoming insignificant. The

arrangement of the various heights attained by the Jews will best be appreciated by observing the curve plotted from these figures. It will be observed on figure 1 the curve on the left side rises steadily until it reaches the point of 162 cm. in height; it does not descend in the same manner, but remains stationary up to 166 cm. It rises again at 171–172, and 174–180, which indicates that there is an excess of tall men among the Jews in New York, and which is best explained by the fact that they are an immigrant population, and emigrants are always

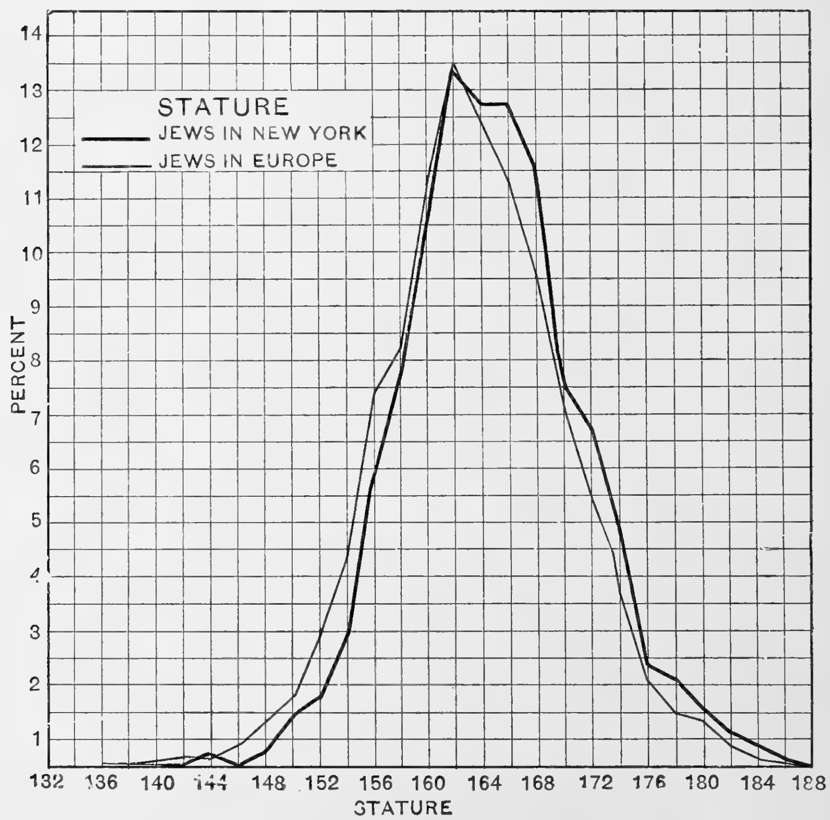

FIG. 2.

taller on the average than the people in their native home. This has been already shown to be a fact with other immigrants from Gould's statistics. The reason assigned is that most of the dwarfed, sickly and infirm remain at home and do not venture on so long a journey. It is mostly the strong, the healthy and the well developed who emigrate. That this is also the

case with the Jews in the United States, is seen from the fact that the average stature in New York City is 164.5 cm., which is much above that observed in eastern Europe. There, Snigirew and Elkind have found that the average height of the Jews in Poland is 161 cm.; in Galicia it has been observed to be 162.3 (Majer and Kopernicki); in Hungary 163.3[1] (Scheiber), etc. Only in south Russia it has been observed that the Jews are as tall as we find them in New York City — 164.5 cm. according to Snigirew and Weissenberg. And the Jews coming here from these regions were found to be much taller than those from other countries, as will be seen later.

To test this point more definitely, we have collected from the literature on the anthropology of the Jews measurements of 1681 Jews in Eastern Europe for comparison with those in New York. These were taken from Majer and Kopernicki, 836 Galician Jews; Talko-Hryncewicz, 506 Russian Jews; Elkind, 200 Polish Jews; and Yakowenko, 139 Russian Jews. It will be seen that this represents nearly all the countries from which the Jews come to the United States, excepting Roumania and Hungary. For the former there is no literature available, and Scheiber's statistics for the latter are not reported in a manner suitable for comparison. Grouping the figures into four divisions, as proposed by Topinard, and considering those who attain less than 160 cm. in height as of "short" stature; 160 to 164.9 cm. as "stature below the average," 165 to 169.9 cm. as "stature above the average," and 170 cm. and over as "tall stature," we find the following proportions:

TABLE IV.

STATURE OF JEWS IN THE UNITED STATES AND IN EASTERN EUROPE.

	Elkind.	Yakowenko.	Talko-Hryncewicz.	Majer & Kopernicki.	Jews, Europe.		Jews, New York.	
					No.	Percent.	No.	Percent.
Short	91	53	152	300	596	35.46	356	23.30
Below the average	57	46	152	291	546	32.48	460	30.10
Above the average	40	27	128	165	360	21.41	420	27.49
Tall	12	13	74	80	179	10.65	292	19.11
Total	200	139	506	836	1,681	100.00	1,528	100.00

From this table (IV) it is seen that individuals of short stature were found in Europe to reach 35.46 percent, while among the immigrant Jewish population in New York City it was only 23.3 percent. Large stature, on the other hand, is among the Jews in Eastern Europe 10.65 percent, and in New York the proportion is nearly double, 19.11 percent. Median height, 160 to 170 cm. in height, is about equally distributed in both groups. The superiority for the stature of the immigrant Jews in the United States as compared with those in Eastern Europe, is depicted to a yet better advantage in the accompanying diagram (Fig. 2),

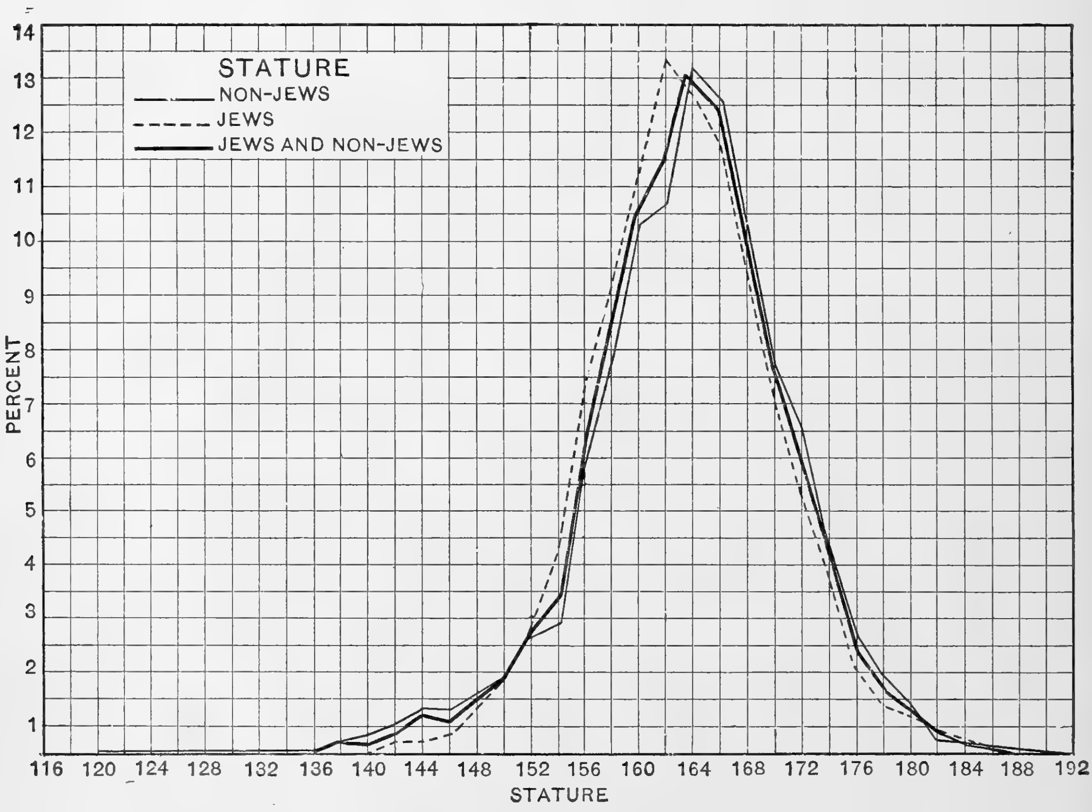

FIG. 3.

constructed from the tables given in the works of the above mentioned authors. The curve for the Jews in the United States is situated more toward the right, while the one for those in Europe, is more to the left, although their course in other regards is almost identical.

TABLE V.

STATURE OF JEWS AND NON-JEWS IN EASTERN EUROPE.

mm.	Jews.		Non-Jews.		Jews and Non-Jews.	
	Number.	Percent.	Number.	Percent.	Number.	Percent.
115–116	—	—	1	0.01	1	0.01
117–118	—	—	—	—	—	—
119–120	—	—	2	0.03	2	0.02
121–122	—	—	2	0.03	2	0.02
123–124	—	—	1	0.01	1	0.01
125–126	—	—	2	0.03	2	0.02
127–128	—	—	1	0.01	1	0.01
129–130	—	—	8	0.12	8	0.08
131–132	2	0.07	12	0.18	14	0.14
133–134	—	—	7	0.10	7	0.07
135–136	1	0.03	8	0.12	9	0.09
137–138	2	0.07	17	0.26	19	0.19
139–140	1	0.03	22	0.32	23	0.23
141–142	10	0.31	37	0.55	47	0.48
143–144	10	0.31	51	0.76	61	0.62
145–146	13	0.40	47	0.70	60	0.61
147–148	27	0.84	74	1.10	101	1.02
149–150	44	1.37	100	1.49	144	1.45
151–152	79	2.46	151	2.25	230	2.32
153–154	119	3.70	164	2.45	283	2.86
155–156	224	6.98	361	5.38	585	5.90
157–158	277	8.63	500	7.45	777	7.83
159–160	341	10.62	652	9.72	993	10.01
161–162	414	12.90	680	10.45	1,094	11.03
163–164	394	12.28	848	12.64	1,242	12.52
165–166	365	11.37	813	12.12	1,178	11.87
167–168	289	9.00	652	9.73	941	9.45
169–170	210	6.54	491	7.32	701	7.07
171–172	155	4.83	408	6.08	563	5.69
173–174	108	3 37	252	3.76	360	3.64
175–176	48	1.52	147	2.19	195	1.97
177–178	30	0.93	97	1.45	127	1.28
179–180	23	0.72	55	0.82	78	0.79
181–182	13	0.40	22	0.33	35	0.35
183–184	7	0.22	15	0.22	22	0.22
185–186	1	0.03	7	0.10	8	0.08
187–188	2	0.07	—	—	2	0.02
189–190	—	—	1	0.01	1	0.01
	3,209	100.00	6,708	99.97	9,917	100.02

On figure 3 is shown a curve constructed from the figures representing both the Jews in Eastern Europe, and in New York City, a total of 3,209 persons. It will be observed that the apex points at 162 cm. which is about the average for the Jews in Europe. Towards the left, where stature below the average

is represented, the curve runs progressively downwards, until the stature of 150 cm. is reached, when the number becomes almost insignificant. But to the right, where heights above the average are shown, a significant point is to be seen. Up to 168 cm. there is shown an elevation of the curve, which is not seen on the curve for the Jews of Eastern Europe, but exactly corresponding to the elevation in the curve representing the Jews in New York City. This again shows plainly the process of selection which is usual for immigrants as regards their physical condition — the taller ones are more adventurous and are more apt to leave their native land in search of fortunes in a distant land.

The first impression one gets while examining this curve is that the Jews do not show any evidences of intermixture with other races. It has been accepted by many anthropologists that the seriation and coördination of any physical character of a people, in which there has taken place an appreciable amount of racial intermixture will not show a smooth curve. It will display more than one apex, corresponding to the racial elements which have entered into the composition of the people. On the other hand, when a curve shows a single apex — one maximum of frequency, around which are clustered all the other observations, the lesser values to the left and the larger to the right, it may be accepted as good proof of the purity of the race. Viewed from this standpoint, the Jews can be considered as pure, showing no evidence of foreign blood in their veins.

The fallacy of such a contention will be evident when we will consider at first the stature of the races and peoples among whom the Eastern European Jews have lived for centuries. They are primarily those whom ethnologists class under the vague term "Slav" races. Of these we find in Poland the Poles, whose stature is quite short, 162 to 164 cm. in height (Majer and Kopernicki, Olechnowicz, Elkind, Snigiref, Zakrzewski, etc.) In Lithuania and White-Russia, the Lithuanians, Letts, and the White-Russians are somewhat taller — 163 to 165 cm. The Little-Russians in South Russia, and the Ruthenians in Galicia are taller, to be sure, but their height does not exceed 166.7 cm. and in some localities it is much lower —

only 162 to 163 cm.[1] In Hungary ethnic conditions are not so simple. Here we have the Magyars who are among the shortest of Europeans, less than 162 cm. in height. The Slavs in that country are taller, being ethnically allied to the Ruthenians of Galicia and the Little-Russians of the Ukraine, this is to be expected — they reach 164.6 cm. The Germans in Hungary are of about the same height (Scheiber). The Roumanians are about midway between the short Poles and Magyars, the tall Little-Russians and Ruthenes. From the recent investigations of Pittard they are found to be 165 cm. in height. A glance at the map prepared by Anutchin and reproduced by Ripley[2] showing the distribution of stature in this region of Europe, will make this point clear.

This is the stature of the races among whom the Jews under consideration have lived for the last eight or ten centuries. If any infusion of foreign blood has taken place, these races must have been the sources from which it came. This we must remember at the outset, before considering the curve showing the distribution of stature of the Jews and Christians in Eastern Europe.

In order that we may see the probable effect of such an intermixture of the Jews with the races among whom they have lived for a longer time, the following plan of investigation has been adopted: We have collected from the anthropological literature on the eastern European races measurements of 6,708 individuals, including:

1,055	Little-Russians, from	Talko-Hryncewicz's		work.
476	Letto-Lithuanians "	"	"	"
961	White-Russians "	"	"	"
2,861	Poles from Galicia "	Kopernicki's		"
1,355	Ruthenians from Galicia	"		"

These have been tabulated in Table V and the percentages of frequency calculated for each group of stature; the results have been plotted on diagram as a curve. A glance at this curve reveals the following salient points. Notwithstanding the fact

[1] Talko-Hryncewicz, Kopernicki, Anutchin, Ivanowski and others.

[2] "Races of Europe," p. 348, and also the map for Austria-Hungary, p. 350.

that it is composed of a group of peoples each of which has no special claim to exceptional racial purity; notwithstanding that, no matter how pure each of these races may claim to be, still a mixture of all of them can not be considered as representing a pure type, — the resulting curve of stature, is as smooth as could be expected of the purest of races.[1] One more point is to be considered of significance: The course of this curve is almost identical with that for the Jews, seen on diagram 3, with one exception, — is situated about two centimeters to the right, thus showing that the Christians of Eastern Europe are on the average about two centimeters taller than the Jews. The apex points at 164 cm., while the one for the Jews points at 162 cm. Considering the conditions of poverty and privation under which the Jews in Eastern Europe are laboring, the indoor occupations in which they are generally employed, and the absence of agricultural laborers among them, we are not surprised at the shortage of about one inch of stature they display, when compared with their non-Jewish neighbors, who are generally under better economic and social conditions, working mostly outdoors, etc. The similarity of stature of the Jews with that of non-Jews of Eastern Europe of which we have already spoken before, is yet more apparent when we consider them not *en masse*, but in groups according to the country they inhabit. This we will do later.

As a further test we have combined the 3,209 Jews with the 6,708 Gentiles and of both sets of figures constructed a curve which is shown on figure 3. This curve again shows no double apex, no significant elevations or indentations in its course, thus again proving that the smooth course of the curve representing the stature of the Jews can not be considered a proof of their racial purity. It is evident that no amount of foreign blood coming from the races of Eastern Europe, among whom the Jews have lived, would have shown itself in a study of the seriation of their stature.

The reason for this condition is evident: The difference in the type of stature of the Jews and Gentiles in Eastern Europe is

[1] The slight indentation at the height of 162 cm. can be ascribed to chance.

very slight — almost insignificant, 162 to 163 cm. for the former, and 164 to 165 for the latter, is about the standard of height for these peoples. Intermixture with people who differ but one to two centimeters in height cannot have any effect on the distribution of stature so as to be evident in a seriation, as can be readily seen on diagram 3. If the difference in stature had been larger, say eight to ten centimeters, supposing the intermixture had taken place with the Scotch, who average over 170 cm. in height, the curve might have shown it up by a double apex.

What we desire to emphasize however at this place, is that the smooth course of the curve for stature of the Eastern European Jews does not exclude the possibility of racial intermixture.

Table VI.

Stature of 1,528 Jews According to their Nativity.

Stature (in cm.).	Galicia.	Poland.	Lithuania and White-Russia.	Little-Russia.	Roumania.	Hungary.	United States.
137–138	0.33	—	—	—	—	—	—
139–140	—	0.31	—	—	—	—	—
141–142	0.33	—	0.36	—	—	—	—
143–144	1.31	—	—	—	—	—	—
145–146	0.98	—	—	—	—	—	—
147–148	0.65	—	—	—	1.33	—	—
149–150	2.95	0.95	—	0.91	—	—	0.80
151–152	3.28	1.59	0.36	0.45	1.33	0.72	—
153–154	3.61	4.13	1.82	0.91	1.33	1.43	1.61
155–156	7.21	7.30	6.18	3.19	4.00	3.57	1.61
157–158	8.53	9.21	6.91	5.02	8.00	7.14	2.42
159–160	12.13	9.84	12.00	7.77	6.67	10.71	5.65
161–162	11.15	15.24	14.55	13.70	10.00	13.57	8.87
163–164	12.46	11.11	13.46	15.53	12.67	7.86	12.10
165–166	10.16	13.97	11.63	13.70	9.33	15.71	12.90
167–168	7.87	10.16	12.72	12.79	10.67	10.72	15.32
169–170	5.90	6.03	5.82	7.31	8.67	8.57	10.49
171–172	6.23	3.49	5.82	8.22	8.67	7.14	7.26
173–174	2.63	1.90	4.36	5.48	8.00	5.00	8.07
175–176	0.98	1.90	1.46	1.37	2.67	2.86	3.23
177–178	0.33	1.59	0.73	1.37	3.33	2.14	3.23
179–180	0.33	0.63	0.36	0.91	1.33	2.14	4.03
181–182	—	0.31	0.73	1.37	0.67	0.72	0.80
183–184	0.65	0.31	0.36	—	1.33	—	—
185–186	—	—	—	—	—	—	0.80
187–188	—	—	—	—	—	—	0.80
No. measured.	305	315	275	219	150	140	124
Average stature.	162.2	163.4	164.2	165.7	166.0	165.7	167.9

On Table VI is shown the individual variations of the stature of the Jews in New York City, according to their nativity. It will be observed that there are noteworthy differences in the stature of each group of Jews. A comparsion of these figures with measurements obtained in Eastern Europe, shows that the immigrants are taller than the Jews in their native countries. Thus, the average stature of the Jews in Poland, was found by Snigireff and Elkind to be 161 cm. while those who left Poland and emigrated to the United States are found to be 163.4 cm. in height. In Lithuania and White-Russia Snigireff, Talko-Hryncewicz and Yakowenko found the average height of the Jews about 162 cm., and immigrants from this region of Russia are seen to be 164.2 cm. on the average. In South Russia Snigireff and Weissenberg measurements show that the Jews are over 164 cm. and the immigrants from this country are found to average 165.7 cm. in height. The same is true of the Jews from Hungary, who in their native land were found to be 163.3 cm. (Scheiber), while those in New York are 2.4 cm. taller, averaging 165.7 cm. The only exception are the Jews from Galicia, who were found by Majer and Kopernicki to be 162.3 cm. in their native land, while in New York they are of the same height. As will be seen later this exceptional phenomenon is not confined to stature; "selection by immigration" is also negative among these Jews as regards their headform. But in all the other groups it appears that the immigrants are taller than those left at home.

This phenomenon appears in a more striking manner when we compare the immigrants with their correligionists at home by grouping the figures obtained by measurement in four groups of stature, short, below the average, above the average and tall. For comparison, the literature of the anthropology of the Jews in Eastern Europe has been utilized, and the figures are presented in table VII.

From this table (VII) it is seen that the proportion of short persons is larger among the Jews in their native lands than among those who emigrated to the United States. 29 percent of the Jews in Little-Russia are less than 160 cm. in height, and

TABLE VII.[1]

STATURE OF IMMIGRANT JEWS IN NEW YORK COMPARED WITH THOSE IN EASTERN EUROPE.

Stature (in cm.)	Galicia.		Poland.		Lithuania and White-Russia.		Little-Russia	
	N. Y.	Galicia.	N. Y.	Poland.	N. Y.	Lithuania.	N. Y.	Lit.-Russia.
— 160	36.07	29.16	29.20	45.50	21.45	38.10	14.60	29.22
160–165	28.85	29.17	30.48	28.50	34.55	33.09	32.87	29.00
165–170	21.64	25.00	27.30	20.00	29.09	19.42	30.58	27.17
170 +	13.44	16.67	13.02	6.00	14.91	9.39	21.95	14.61
— 165	64.92	58.33	59.68	74.00	56.00	71.19	47.47	58.22
165 +	35.08	41.67	40.32	26.00	44.00	28.81	52.53	41.78

only 14 percent of the Jewish immigrants from that country are in this class of stature; in Lithuania the proportions are 38 to 21 percent. The only exception is again with the Galician Jews, where the proportion of persons less than 160 cm. in height was found by Majer and Kopernicki to be 29 percent and in New York City such short persons are more frequent, reaching 36 percent. Tall individuals, 170 cm. in height and taller, are more frequently met with among the immigrants than among those measured in their native land, again with the exception of the Galicians. Among the Little-Russian Jews this class of stature is 21.95 percent in New York and only 14.61 percent at home; among the White-Russian and Lithuanian Jews 14.91 in New York and 9.39 percent at home; and among the Polish Jews 13 percent in New York and 6 percent in Poland. The same is the fact with the Hungarian Jews when we compare our statistics with those obtained by Scheiber in Hungary.[2]

[1] The figures for the Jews in eastern Europe in this table are taken from: Galicia, Majer and Kopernicki, "Charakterystyka fizyczna ludnosci galicyzskiej," *Zbior wiadom. do antropol. krajowej*, Krakow, 1877, 1885, Vols. I and X; Poland, A. D. Elkind, "The Jews," Publications of the Society of Friends of Natural Science, Anthropology and Ethnography, Vol. XXI, Moscow, 1902 (in Russian); Little-Russia, J. Talko-Hryncewicz, "Charakterystyka fizyczna ludnosci zydowskiej Litwi i Rusi," *Zbior wiad. do antropol. Kraj.*, Vol. XVI, 1892; White-Russia, M. G. Yakowenko, "Materials for the Anthropology of the Jews," St. Petersburg, 1898 (in Russian).

[2] S. H. Scheiber, "Untersuchungen über den mittleren Wuchs der Menschen in Ungarm," *Archiv für Anthropologie*, II, 1881, pp. 233-267.

For comparison of the Jews with the indigenous population of the countries in which they lived for centuries it has been deemed advisable to combine the figures obtained by measurement of the Jews in New York with those found in the anthropological literature of the Jews in eastern Europe. A fairly large number of observations are thus obtained, which may be expected to give more or less definite results. We have thus tabulated 1,141 Galician Jews (305 in New York and 836 in Galicia by Kopernicki); 515 Polish Jews (315 in New York and 200 in Poland by Elkind); 414 Lithuanian and White-Russian Jews (275 in New York and 139 in White-Russia by Yakowenko); 657 Little-Russian Jews (219 in New York and 438 in Little-Russia by Talko-Hryncewicz). These figures are placed in parallel columns with Galician Poles and Ruthenians (Majer and Kopernicki), Poles (Elkind), Letto-Lithuanians and White-Russians (Talko-Hryncewicz, and Little-Russians (Ivanowski), and Roumanians (Pittard).[1]

An analysis of the figures in this table confirms in a striking manner the similarity of the stature of the Jews to that of their non-Jewish neighbors. To begin with the average stature: In Galicia it is equal to that of the Poles of that country, and less than that of the Ruthenians who are known to be tall. In Poland the Jews are slightly taller, and here the Poles are also taller than those of Galicia. In White-Russia and Lithuania the Jews are taller than those in the above-mentioned countries, and here we find that the indigenous population is also taller than the Poles; while in Little-Russia, where the people are distinguished by their superior height (being among the tallest of races of European Russia) the Jews are also tall. Weissenberg found them here to measure 164.8 cm. in height, and Pan-

[1] Majer and Kopernicki, *loc. cit.;* A. D. Elkind, "The Poles of the District of Wisla," *Public. Soc. of Friends of Natural Science Anthropol. and Ethnography*, Vol. XC, Moscow, 1897; J. Talko-Hryncewicz, "Charakterystyka fizyczna ludu ukrainskiego," *Zbior Widom. do. Antrop. krj.*, Vol. XIV; *idem.*, "Charakterystyka fizyczna ludow Litwi i Rusi," *ibid*, Vol. XVIII; A. A. Ivanowski, "On the Anthropological Composition of the Races in Russia," *Public. Society of Friends, etc.*, Vol., CV., Moscow 1904 (in Russian); Eugene Pittard, "Anthropologie de la Roumaina," *L'anthropologie*, XIV, No. 1, 1903, pp. 33-58.

TABLE VIII.

STATURE OF THE JEWS COMPARED WITH THAT OF NON-JEWS IN VARIOUS COUNNTRIESI EASTERN EUROPE.

Country.	Less Than 160.	160 to 164.9.	165 to 169.9.	170 and Over.	Less Than 165.	165 and Over.	Number.	Average Stature.	Observer.
Galicia.									
Jews.	35.93	33.22	20.24	10.61	69.15	30.85	1,141	1,623	Fishberg, Kopern.
Poles.	13.67	32.93	28.90	24.50	46.60	53.40	2,861	1,622	Kopernicki.
Ruthenians.	21.78	26.47	22.94	28.81	48.25	51.75	1,355	1,640	"
Poland.									
Jews.	35.53	29.71	24.47	10.29	65.24	34.47	515	1,625	Fishberg, Elkind.
Poles.	23.50	38.22	21.99	16.23	61.78	38.22	191	1,640	Elkind.
Lithuania and White-Kussia.									
Jews.	27.05	34.06	25.85	13.04	61.11	38.89	414	1,635	Fishberg, Yakowenko.
White-Russians.	23.93	28.62	32.15	15.14	52.55	47.29	961	1,636	Talko-Hryncewicz.
Letto-Lithua.	18.07	31.52	27.94	22.47	49.59	50.41	476	1,644	Talko-Hryncewicz.
Little-Russia.									
Jews.	24.35	30.30	28.31	17.04	54.65	45.35	657	1,639	Fishberg, Talko-Hryncewicz.
Little-Russians.	14.52	32.88	26.86	25.74	47.40	52.60	1,694	1,670	Ivanowski.
Roumania.									
Jews.	18.00	27.33	24.00	30.67	45.33	54.67	150	1,660	Fishberg.
Roumanians.	12.58	29.80	31.79	25.83	42.38	57.62	151	1,650	Pittard.

tukhof records the Jewish recruits in Odessa to be 165.6 cm. in height on the average, even taller than the Christian conscripts of that city. Even Snigireff's recruiting statistics show that the Jews measure here 164.2 cm. The Hungarians are also known to be tall, 164.6 cm., according to measurements of 77,579 Magyar soldiers,[1] and here, also, the Jews are taller, 165.7 cm. in height.[2] Finally the Roumanian Jews appear the tallest of the Eastern European immigrant Jews in New York city. Pittard gives as the average stature of the Roumanians as 165 cm.; the same average stature was found by measuring

[1] Quoted from Deniker, "The Races of Man," p. 579.

[2] From Scheiber's statistics it would appear that the Magyars are shorter, only 161.9 cm., but he found the Jews superior in this respect, 163.3 cm. in height. The difference may be explained by the fact that the former statistics are from soldiers, a picked lot from which all short individuals have been eliminated.

59,761 Roumanian soldiers;[1] in Bukowina, Himmel records that the Roumanians reach 167.3 cm. in height.[2] We found no records in anthropological literature of measurements of Jews in Roumania, but from Himmel's measurements of 100 Jewish soldiers in Bukowina, they are shown to be quite tall, 165.7 cm. on the average.

It is noteworthy that the distribution of the classes of stature confirms this condition very strikingly. It appears from this table that the proportion of short individuals, less than 160 cm. in height, is everywhere larger among the Jews than among the Gentiles of the same country (excepting among the Roumanians, but here we deal with immigrants only, having no available statistics for Jews in their native country to combine with the statistics of the stature of the immigrants as was done with the other groups). But the percentage of these short individuals seems to run in almost direct ratio to the percentage found among the Gentiles in the same locality. In Galicia and in Russian Poland, where persons under 160 cm. in height reach over 20 percent, the Jews have 35 percent of short men; on the other hand, in Little-Russia, where such people are only found to the extent of 14 percent, and in Roumania where it is only 12 percent among the Gentiles, the Jews show also a lesser proportion, 24 and 18 percent respectively. Persons of tall stature, 170 cm. in height and taller, are met with less frequently among the Jews than among non-Jews of the same country. Such persons are found to the extent of 10 percent among the Galician Jews, but the proportion increases in frequency as it increases among the Christians of a given country, and is found to be 17 percent among the Jews from Little-Russia, and even 30 percent among the Roumanian Jews. That this is not an isolated case, is shown by the fact that Talko-Hryncewicz, Majer and Kopernicki and Otto Ammon mention the fact that in those parts of the country[3] where the general

[1] Deniker, *loc. cit.*

[2] See Himmel's "Körpermessungen in der Bukowina," reported by Weisbach, in *Mittheilungen Anthropol. Gesellschaft Wien*, XVIII, 1888, *Sitzungsbericht*, pp. 83–84.

[3] Little-Russia, Galicia, Baden.

population is of tall stature, the Jews display the same characteristic, and the reverse.

The Influence of Social Conditions on Stature.

The deficiency of the stature of the Jews, as compared with their non-Jewish neighbors is an interesting topic for investigation. It is true that the difference is but little, only one to three centimeters in favor of the Gentiles, but it is evident in almost every country where measurements have been taken. It is of scientific interest to inquire into the reasons why the stature of the Jews depends to a great extent upon the statute of their neighbors, wherever the latter are short of stature the Jews display the same characteristic; and the reverse, but what is most remarkable, they are always somewhat shorter than the Gentiles.

One reason may be the fact that the Jews are mostly town-dwellers, while nearly two thirds of non-Jews are living in the country. The Jews are only rarely engaged in agricultural pursuits. "The general rule in Europe" says Ripley, "seems to be that the urban type is physically degenerate."[1] Beddoe considers as proved that the stature of men in the large towns of Britain is lowered considerably below the standard of the nation and that such degradation is progressive and hereditary.[2] The same has been observed by Ranke in Bavaria,[3] Anutchin in Russia[4] and by many others. Ripley[5] points out that "the unfavorable influence of city life is often obscured by the great social selection which is at work in the determination of the physical type of the population of great cities. While the course of the town type by itself is downward, oftentimes the city attracts another class which is markedly superior, in the same way that the immigrants of the United States have been distinguished in this respect." This advantage is of course not enjoyed

[1] *Loc. cit.*, p. 95.

[2] J. Beddoe, "On the Stature and Bulk of Man in the British Isles," *Mem. Anthr. Soc. London*, III, 1867.

[3] J. Ranke, "Der Mensch," Vol. II, p. 131.

[4] D. N. Anutchin, "On the Geographical Distribution of Stature of the Male Population of Russia, St. Petersburg, 1889, p. 165 (in Russian).

[5] *Loc. cit.*, pp. 95, 552–555.

by the Jews in Europe, because the numerical value of the Jewish rural population is almost insignificant. The superior stature of the Jews in the United States is to be ascribed to this very cause.

The wretched social, economic and sanitary conditions under which they labor in the Eastern European Ghettoes, will also account for the deficiency they display in body height, when compared with their Gentile neighbors. As a matter of fact, in Galicia, where the economic conditions of the Jews are worst, they are shorter than any other class of Jews. Even the immigrants of the United States from this poor country are the shortest, as we have seen above. The artificial selection which influences favorably the average stature of immigrants, had no effect at all on these Jews. In Poland, where the economic conditions are better, the Jews are taller; while in South Russia the Jews are quite tall, corresponding possibly to superior economic conditions. The influence of poverty and social conditions on the stature of the Jews has been illustrated in a striking manner by Zakrzewski in his work "Ludnosc miasta Warszawy."[1] He prepared maps showing the social status of the various districts in Warsaw, the capital of Poland and the average stature of the Jews and Poles in that city. A comparison of these maps shows in a striking manner how shortness of stature goes hand in hand with poverty. Another indirect proof of this theory is the increase of stature of the first generation of Jews in New York city, where the social and economic conditions are much improved.

The Jews are mostly engaged in indoor occupations. 720 of the 1528 individuals investigated in New York (47.12 percent) were working indoors. That workingmen who spend most of their time in closed rooms, particularly amid unsanitary surroundings, such as are generally obtainable in sweatshops, are shorter of stature, is well known. Ripley ascribes it to two causes: The first is artificial selection, "The physically well developed men seek certain trades or occupations in which their vigor or strength may stand them in good stead; on the other

[1] *Materiali antr.-archeol. Akad. umiej.*, Krakow, I, dzial I, pp. 1–38.

hand, those who are by nature weakly, and coincidently often deficient in stature, are compelled to make shift with some pursuit for which they are fitted. Thus workers in iron, porters, firemen, policemen, are taller as a class than the average, because they are of necessity recruited from the more robust portion of the population. In marked contrast to them, tailors, shoemakers and weavers, in an occupation which entails slight demands upon the physical powers, and which is open to all, however weakly they may be, are appreciably shorter than the average." The second cause is the result of the effects of the habits of life or of the nature of the employment. The conditions in the sweatshops act adversely on the physique of the younger tailors. Add to this the cramped position in which they work, the long hours, the unsanitary surroundings, etc., and you find all the conditions tending to physical degeneracy.[1]

TABLE IX.

STATURE AND OCCUPATION.

Occupation.	Number Observed.	Average Stature (cm.).	Short Stature.	Stature below the Average.	Stature above the Average.	Tall Stature.
Indoor.						
Tailors.	372	161.3	32.79%	33.33%	22.05%	11.85%
Cobblers.	79	160.4	37.98	26.58	27.80	11.83
Fact'y workers.	269	162.2	26.39	27.89	30.11	15.61
Total indoor.	720	162.0	30.98	30.58	25.69	12.17
Outdoor.						
Carpenters.	89	164.9	19.10	31.46	28.09	21.35
Iron-workers.	68	166.3	20.59	26.47	27.94	25.00
Masons.	44	167.9	15.92	31.83	28.09	21.35
House painters.	58	167.5	15.52	25.86	31.03	27.59
Laborers.	85	166.8	29.41	22.35	29.41	18.83
Total outdoor.	344	166.4	20.93	27.32	28.78	22.97
Mercantile.						
Merchants.	163	168.7	16.56	27.61	31.90	28.83
Clerks.	105	169.2	11.42	35.21	26.67	26.67
Peddlers.	130	164.3	18.47	37.69	26.15	17.69
Professional.	66	169.6	9.04	22.73	33.33	34.85

In order to determine whether the peculiar occupations of the Jews had any effect on their average stature, I have classified

[1] W. Z. Ripley, "Races of Europe," pp. 89–93.

the material according to the occupations of the people who submitted to measurement. The average stature of each class was calculated, and also the percentage of people of tall, medium and short stature among them. Among these 1,528 men under consideration, 720 (47.12 percent) were engaged in indoor occupations, including the various branches of tailoring, cobblers, cigar-makers, weavers, bakers, etc. ; 344 (22.51 percent) were working outdoors, including carpenters, house painters, masons, ironworkers, etc. ; 398 (26.65 percent) were engaged in mercantile pursuits, as clerks, etc., 130 were peddlers ; 66 in the class generally called professional class, including the liberal professions and also students. The accompanying table (IX) shows the results of this inquiry. It will be observed that the tallest were the professional men reaching 169.9 cm. in height. They also had the largest proportion of tall men — 34.85 percent. The clerks and merchants come very close with 169.2 and 168.7 cm. respectively, in height. Beside these we note the peddlers, who though classed with the merchants, still are rather short, only 164.3 cm. The reason is apparent, the percentage of short people among them was 18.47, and tall, 170 cm. and over only 17.60. Coming to the people engaged in outdoor occupations we note that their average stature was 166.4 cm., two cm. above that for the Jews in New York City. Nearly 23 percent of them were 170 cm. and over in height as against only 19 among the Jews generally, and while the latter show 23.3 percent of short people averaging less than 160 cm. in height, such who are engaged in outdoor occupations, have only 20.93 percent of such deficient persons.

Masons and house painters were the tallest of this class while the carpenters were the shortest. When we come to consider those engaged in indoor occupations, we are at once struck by the alarming proportion of short people, 30.98 percent were less than 160 cm. in height, and in addition to this the proportion of tall persons, 170 cm. and over, are found to be only 12.17 percent. We can add that only one of these was 178 cm., six feet tall, and he was not a tailor in his early years ; only after emigrating to the United States at the age of twenty-one he

learned the trade. Their average stature is only 162 cm., 2.5 cm. (one inch) shorter than the general average for the Jews in New York City. Deplorably deficient in this regard were found the cobblers and tailors, 160.4 cm. for the former, and 161.3 for the latter. The proportion of short men was 32.79 among the tailors and reached nearly 38 percent among the shoemakers.

These figures, though based on comparatively few observations tend to show that the deficiency of the Jews' stature, as compared with the other races in eastern Europe, may at least partly, be ascribed to the wretched social and economic conditions under which he finds himself within the gates of the Eastern European Ghettoes. Dr. S. Weissenberg also observed that the stature of the Jews in South Russia depends greatly on their occupations and social status, and Zakrzewski's maps of the city of Warsaw confirm this in Poland — the largest Jewish center in Europe. The first generation of Jews in New York City, which only rarely works at indoor occupations, lead a more active open-air life, which is conducive to normal growth and development, are also taller. This condition also confirms that the shortness of stature of the Jews is due in a great measure to their social conditions and environment.

The influence of occupation, active open-air life and general prosperity on the stature of the Jews, is best seen from Mr. Joseph Jacobs' measurements of English Jews. He found the average height of the Jews in London was 164.1 cm. (65 inches), but the Jews living in the "West-End" of London were much taller, they averaged 171.4 cm. (67.5 inches). Jacobs attributes this superior stature of the "West-End" Jews to their superior "nurture," and social conditions generally.[1] An analysis of the stature of the Jews born in the United States, as compared with that of their foreign-born parents, confirms Jacobs' observations on English Jews. Among the 1,528 Jews under consideration 124 were native born. Their average stature was 167.9 cm., as against 164.2 cm. of the 1,404 Jews of foreign birth. This

[1] Joseph Jacobs, "On the Comparative Anthropometry of English Jews," *Journal Anthropological Institute, London*, XIX, 1890, pp. 76-88.

shows an increase of 3.7 cm. in the first generation. The increase in stature is yet better displayed in the accompanying table showing the proportion of individuals at a given class of stature accordingly to the four divisions of stature in which our material has been divided.

Table X.

Stature of Native and Foreign Jews.

Stature.	Foreign Jews		Native Jews.	
	Number.	Percent.	Number.	Percent
Short.	345	24.57	11	8.87
Below the Average.	430	30.63	30	24.19
Above the Average.	379	26.99	41	33.07
Tall.	250	17.81	42	33.87
Total.	1404	100.00	124	100.00

From this table we find that while among the Jews born in Eastern Europe 24.57 percent were of short stature (less than 160 cm.), there were only 8.87 percent of native Jews thus deficient in body-height. On the other hand, tall men, 170 cm. in height and upward, are found among the native Jews 33.87 percent, as against only 17.81 percent. among their immigrant parents. The proportion of persons of medium height, 160 to 170 cm., is about the same in both groups.

We can see in this a process of double selection at work. The immigrants are taller on the average than the people of whom they spring, as we have already seen. That stature is transmitted by heredity is not to be questioned. When to this are added other factors which are favorable to healthy growth of the body, we have good reasons for the superior stature of the native American Jews. Here during the period of most active growth, the Jewish child attends a modern public school, instead of the insanitary "Cheder" (Jewish school) in Eastern Europe; during adolescence the Jew here engages mostly in outdoor occupations, instead of the sweatshops which is the work shop of many of the immigrant Jews (only five of the 124 native Jews were engaged at work in sweatshops). Besides this, the native Jewish youth in the East side in New York City enjoys

quite freely open air recreations, games, bicycle riding, etc., all of which is conducive to healthy growth and development of the body.

The superior stature of the native American Jews is thus seen to be a result of superior social conditions and environment.

Stature of Women.

The average stature of 435 women examined by the present writer is 153.5 cm (5 feet, 0.4 inch.) They are thus 11 cm. shorter than the men. The ratio of stature of men and women is 1 to 0.931 or as 16 to 14.88, which is exactly the ratio of adult men and women in England.[1] The absolute difference in stature between men and women is about the same as generally observed in other races, as can be seen from Deniker's study of 35 series of measurements of women, that in 20 cases out of 35, *i. e.*, almost two thirds, the difference in height between the two sexes in any given population hardly varies more than from 7 to 13 cm. (3 to 5 inches); 14 times out of 35 it only varies from 11 to 12 cm., so that the figure of 12 cm. may be accepted as the average.[2] From investigations of Professor Franz Boas among American Indians, it is to be seen that among the taller American races the stature of women is 92 percent of that of the men, while among the shorter races the percentage reaches 94.[3]

The tallest Jewess examined was 170.3 cm., being 16.8 cm. or 10.94 percent larger than the average. The shortest was 133.4 cm., 20.1 cm., or 13.99 percent shorter than the average. In general the extreme variation extended over 36.9 cm., or 24 percent of the average. All these values are much smaller than those presented by the men, thus showing a much smaller range of variability of stature of the women. The standard deviation was found to be 6.20, which is practically the same as that for

[1] There the stature of men is 170 cm. and of women 160 cm., the ratio is thus as 16 to 14.88. See Report of the Anthropometric Committee, of the British Association, 1883.

[2] J. Deniker, "The Races of Men," London, 1900, p. 33.

[3] Franz Boas, "Zur Anthropologie der nordamerikanischen Indianer," *Verhandung. d. Berliner Anthropologischen Ges.*, 1895, pp. 74, 75.

the men (6.58), while the probable error is 0.20 — larger than that of the men (0.1133). This is due to the smaller number of observations on women, because the average is more accurate, and the probable error consequently smaller, the larger the number of individuals measured.

Arranged in groups of tall, short, etc., we find the following distribution:

	Number.	Percent.
Short (139 cm. and less)	7	1.61
Below the average (140 to 152 cm.)	186	42.76
Above the average (153 to 157 cm.)	142	32.65
Tall (158 and above)	100	22.98
Total	435	100.00

Table XI.

Stature of Jewesses.

Height (in cm.).	Number.	Percent.	Height (in cm.).	Number.	Percent.
133–134	1	0.23	153–154	58	13.34
135–136	2	0.46	155–156	65	14.94
137–138	2	0.46	157–158	39	8.96
139–140	5	1.15	159–160	37	8.51
141–142	9	2.07	161–162	20	4.59
143–144	10	2.29	163–164	6	1.38
145–146	39	8.96	165–166	7	1.61
147–148	40	9.19	167–168	9	2.07
149–150	39	8.96	169–170	1	0.23
151–152	46	10.57	Total.	435	99.97

The seriation of the values obtained by measurement is shown in Table XI and a curve drawn from these figures can be seen on diagram I. Here we observe a narrow pyramid, much higher and narrower than the one for the stature of the men, showing a lesser degree of variability, on the part of the women. The apex points at 152 cm., where nearly fifteen per cent. of the observations are found.

No definite conclusions can be drawn from the figures in table XII showing the individual variations of the stature of Jewesses according to their nativity. The number of observations in each group is too small to give reliable results. Adapting, however, the plan pursued while discussing the stature of the Jews it is

Table XII.

Stature of 435 Jewesses According to Their Nativity.

Stature (in cm.).	Galicia.	Poland.	Lithuania and White-Russia.	Little-Russia.	Roumania.	Hungary.
133–134	—	1.79	—	—	—	—
135–136	—	1.79	1.00	—	—	—
137–138	1.64	—	—	—	—	—
139–140	3.28	—	1.00	—	—	—
141–142	3.28	3.57	1.00	—	2.27	2.56
143–144	1.64	—	4.00	2.70	4.55	2.56
145–146	11.48	8.93	7.00	12.16	2.27	7.69
147–148	11.48	8.93	12.00	6.76	4.55	5.13
149–150	6.55	14.29	11.00	9.46	2.27	10.26
151–152	13.11	12.50	12.00	4.05	11.36	7.69
153–154	7.38	12.50	14.00	18.92	20.45	12.82
155–156	20.49	17.86	13.00	6.76	15.91	12.82
157–158	4.09	3.57	10.00	12.16	13.64	17.95
159–160	9.02	8.93	10.00	5.41	6.82	7.69
161–162	1.64	3.57	2.00	10.81	11.36	2.56
163–164	1.64	—	—	2.70	2.27	2.56
165–166	1.64	—	1.00	2.70	2.27	2.56
167–168	1.64	1.79	1.00	4.05	—	5.13
169–170	—	—	—	1.35	—	—
171–172	—	—	—	—	—	—
No. measured.	122	56	100	74	44	39
Av. stature.	152.4	152.2	153.7	154.6	154.5	154.4

found that the Jewesses confirm in a large measure the conclusions arrived at while discussing the former. This is seen in Table XIII giving the stature of the Jewesses in New York and in Eastern Europe in four classes, small, below the average, above the average and tall, for such as statistics were obtainable in anthropological literature.

Table XIII.

Stature of Jewesses in the United States and in Eastern Europe.

Stature (in cm.).	Poland.		Lithuania and White-Russia.		Little-Russia.	
	N. Y.	Poland.	N. Y.	Lithuania.	N. Y.	Little-Russia.
-140	3.57	0.8	1.0	5.0		1.45
140–152.9	48.21	67.2	48.0	57.0	35.14	59.22
153–157.9	30.36	22.4	31.0	25.0	32.43	23.80
158 +	17.86	9.6	20.0	13.0	32.43	15.53
No. observed.	56	125	100	100	74	206
Average.	152.2	150.0	153.7	150.7	154.6	151.5

This shows that the immigrant Jewesses are on the average taller than those in Eastern Europe. In Poland Elkind found the average stature of the Jewesses in Warsaw to be 150.4 cm. while the immigrants from that country are 152.2 cm.; Lithuanian and White-Russian Jewesses average 150.7 cm. in height at home (Yakowenko), and 153.7 in New York; and Little-Russian Jewesses are 151.5 cm. (Talko-Hryncewicz) in South Russia and in New York 154.6 cm. The proportion of tall Jewesses, over 158 cm. in height is also larger among the immigrants in the United States, than among those in their native homes, 17.86 percent against only 9.6 percent among the Polish; 20 against 13 percent among the Lithuanian, and even 32.43 percent against 15.53 among the Little-Russian Jewesses. it appears, however, that short Jewesses, measuring 140 cm. and less are more frequently encountered among the immigrants than in Eastern Europe, reaching even 3.57 percent among the Polish Jewesses in New York.

TABLE XIV.

STATURE OF JEWESSES COMPARED WITH EASTERN EUROPEAN WOMEN.

Stature.	Poland.		Lithuania.			Little-Russia.	
	Jewesses.	Poles.	Jewesses.	Letto-Lithuanian.	White-Russian.	Jewesses.	Little-Russian.
-140	1.66	—	3.0	—	—	1.07	—
140-152	61.33	46.31	52.5	33.96	43.97	52.86	22.98
153-157	24.86	36.23	28.0	45.29	31.92	26.07	39.57
158 +	12.15	17.45	16.5	20.75	24.11	20.00	37.45
Number.	181	149	200	106	141	280	235
Average.	151.7	153.3	152.2	152.6	152.3	152.6	154.5

When compared with non-Jewish women in the same country, the Jewesses are shorter in stature, by one to two cm., and short persons, 140 cm. in height and less, are entirely absent among the non-Jewish women. The proportion of tall women, 158 cm. and over is much smaller among the Jewesses. But also here we can note the phenomenon observed when considering the men: the proportion of tall individuals is in direct ratio to the proportion of such persons found among the Gentile women. The Polish women have only 17.45 percent of women over 157 cm.

in height, and the Jewesses from that country, 12.15 percent. In Lithuania and White-Russia we find tall women among the Letto Lithuanians to the extent of 20.75 percent, among the White-Russians 24.11 percent, and the Jewesses from this region of Russia show 16.5 percent; and among the Little-Russians, who are known among the tallest Slavonians, the Jewesses have 20 percent of persons over 157 cm. in height, perhaps because the Gentiles here have 37.45 percent of tall women.

It thus appears that notwithstanding the fact that we deal here with only a limited number of observations, measurements of only 661 Jewesses being available, still the results confirm the conclusions reached when studying the men. Their stature depends greatly on the stature of the indigenous population of the country of their birth. Wherever the Gentiles are short of stature, the Jews also are short, and the reverse.

CHAPTER III.

The Girth of the Chest.

The discussions on the girth of the Jewish chest has occupied many pages of the anthropological literature of the Jews. As is well known, the girth of the chest exceeds, or at least equals one half the body height in most people. The measurements taken on thousands of Jewish conscripts in the Eastern European armies have shown the Jewish recruits to be deficient in this regard. From Snigirew's extensive statistics it is seen that measurements taken on 4,470 Jewish recruits in Poland have given an average circumference of the chest of 80.1 cm. (31.5 inches) As their average stature was 162.2 cm., the girth of their chest was only 49.68 percent of their body height. Among 2,122 Jews in Lithuania the same authority has found a girth of only 49.55 percent of their stature. Majer and Kopernicki have found that the girth in 569 Galician Jews was only 49.2 percent The non-Jewish population of these countries have a chest. girth which exceeds half their body height by from two to eight percent. This deficiency of the Jews in girth has given rise to a considerable amount of discussion as to whether the Jews, owing to their deficiency in "vital capacity," and having a lesser "index of vitality," are fit for military duty.[1] Ripley, on reviewing this subject says that the Jews are "anthropologically as well as proverbially, narrow chested.[2]

Of the Jews recorded in this work only 983 have been examined as to the circumference of the chest. Many submitted to the ordeal of having their heads, etc., measured, but they declined to undress for the purpose of having their chest measured. Among these we find an average girth of 85.87 cm., or 52.2 per-

[1] See Snigirew, "Materials for Medical Statistics and Geography of Russia," *Voyeno-Medizinsky Zhurnal*, 1878–9; Goldstein, "Des circonferces du thorax et de leur rapport à la taille," *Revue d'Anthropologie*, serie, 2, VII, pp. 460–485; B. Blechman, "Ein Beitrag zur Anthropologie der Juden," Dorpat, 1882.

[2] Races of Europe, p. 582.

cent of their stature (85.87 ÷ 164.5 = 52.2). The man with the largest chest measured 109 cm. while one had a girth of only 70 cm. This shows that the extreme variations extended over 39 cm. or 45.46 percent of the average which is much larger than the extreme variations found for stature. The fact that the size of the chest is much more exposed to various external influences than is stature, accounts for it. It also shows that the chest can not be considered a stable racial trail.

TABLE XV.

GIRTH OF THE CHEST.

Girth (in cm.).	Number.	Percent.	Girth (in cm.).	Number.	Percent.
69–70	1	0.10	91–92	63	6.41
71–72	4	0.40	93–94	51	5.19
73–74	16	1.63	95–96	16	1.63
75–76	31	3.16	97–98	14	1.43
77–78	56	5.70	99–100	9	0.92
79–80	96	9.77	101–102	4	0.40
81–82	116	11.80	103–104	3	0.30
83–84	135	13.73	105–106	2	0.20
85–86	144	14.65	107–108	2	0.20
87–88	120	12.21	109–110	1	0.10
89–90	99	10.07	Total.	983	100.00

In the accompanying, Table XV, are given the individual variations of the girth of the chest at intervals of 2 cm. It is to be seen that the largest number of people had a girth of 85–86 cm. corresponding to the average and the median. Above and below this value the proportion of persons at a given girth is progressively growing smaller. This points to a certain uniformity of type which is observed in almost all the somatic characteristics of the Jews.

The fact disclosed by these figures that the immigrant Jews in New York have a girth of chest which exceeds half their stature by 3.6 cm. does not contradict the figures quoted from Snigirew, Kopernicki, etc. A careful inquiry reveals that the deficiency in girth of the Jews is not a racial trait, but entirely due to social conditions and tardy development. The Jewish children are known for their precocity in mental and intellectual development. The success they have in the public schools

bears good witness to this. But as regards their physical development the Jewish youth is very slow. While the Slavs among whom they live reach their full growth at 21 to 25 years of age, the Jews do not reach their full height until the age oi 30 and even later. Weissenberg, Elkind, Majer and others have shown this to be the case with the Jews in Eastern Europe. From materials collected by the author, to be published in due time, this also appears to be the case with the Jews in the United States. This condition must be considered while speaking of their girth. It is a striking fact that wherever data have been collected on conscripts whose age ranges between 20 and 21 years, when they have not yet reached their full development, the results show that the girth is less than half their body-height. On the other hand all the measurements which were taken on the general Jewish population, including all ages above 21 years, show quite different results. Weissenberg found that the girth of the Jews in South Russia is 53.6 percent of their stature; Yakowenko in White-Russia, 52.45 percent; Elkind in Poland, 51.57 percent, etc. Our own measurements give a result of 52.2 percent. All this is explained by the age of the persons measured. Those less than 22 years are deficient in girth, those above this age are fairly well developed, because, as has been statistically shown by Weissenberg and Elkind, the bodies up to the age of adolescence grows very rapidly in length, while the width of the body does not grow correspondingly. After twenty years the growth in width begins to be more active, and continues even after the growth in height has ceased. The girth keeps on increasing in size up to the age of forty and even fifty.

The causes of this tardy development are to be sought for in the social conditions of the Jews. The Jew in Eastern Europe does not enjoy during his childhood any games and outdoor exercises, but is confined the greater part of the day in the "Cheder" (Jewish school), which is always in a deplorable sanitary condition. During adolescence his sedentary habits, indoor, domestic occupations and the absence of physical culture are conspicuous. All this does not contribute much to

the healthy development of their muscular system and their chests remain flat and contracted. It must be recalled that the girth depends not only on the size of the skeleton, but also, in a great measure, on the condition of the muscular system. Well developed muscles will enlarge the circumference of the chest with their bulk, and weak, flabby muscles do not elevate the ribs upwards to a perceptible extent, and permit them to hang down at an acute angle in relation to the spinal column, thus reducing the size of the girth. Individuals with strong, well-developed muscles have consequently large chests. The absence of agricultural laborers among the Jews is also an important factor. The rural population is known to have a larger girth than the town dweller, as is the case with the factory worker, who is at a disadvantage in this regard when compared with the outdoor laborer. It has also been observed that the more intellectual classes are quite often deficient in respect to their girth, and Otto Ammon, speaking of this condition, mentions that the Jews are deficient in their chest capacity, because they are assiduously engaged in study in a sitting posture, and also because they are very frequently engaged in mercantile pursuits.[1] He ascribes this defect of the physical organization of the Jews mostly to their faulty muscular development.

For 118 native Jews of New York City we have found the average circumference of the chest to be 88.09 cm., which is more than 2 cm. larger than that of the immigrant Jews in this city, but when considered in relation to stature we find no improvement at all. As the average stature of the native Jews is 1,679 mm., the girth is only 52.46 percent of the body-height, which is about the same as that of their foreign parents. This confirms Ripley's opinion that, even if granted that the narrow chest of the Jews is an acquired characteristic, the effect of long-continued subjection to unfavorable sanitary and social environment, it has none the less become a hereditary trait.

The relations of stature to girth is interesting. Pantukhof has observed in Odessa, South Russia, that the chest of the taller Jews was more capacious than that of the Jews of inferior

[1] Otto Ammon, "Die natürliche Auslese beim Menschen," Jena, 1893, p. 134.

stature. He considers it another proof of the greater vitality of the "Aryan" elements among the Jews, particularly because the taller Jews were also fairer in complexion than were the shorter Jews.[1] From our own measurements we find that the relations of the chest girth to stature was as follows:

Stature.	Average stature.	Average girth.	Percent of stature.	Number of Observations.
Tall stature.	173.4	88.03	50.76	204
Above average.	167.2	86.19	51.58	280
Below average.	162.6	84.36	51.88	288
Short.	156.1	83.12	53.25	205
All Jews.	164.5	85.87	52.2	977

This shows that the *absolute* average girth of the chest increases with the increase of stature, but that the *relative* size of the chest decreases. In other words, the shorter men had relatively larger chests than the taller men. Thus, those who were shorter than 160 cm. in height, had a chest averaging only 83.12 cm., those who were 170 cm. and taller, had an average chest circumference of 88 cm. But relative to stature the shorter people, had a girth of 53.25 percent of the height of the body, while the taller individuals' girth was only 50.76 percent of their stature. If we accept that the average girth for all the Jews as 85.87 cm. or 52.2 percent of their stature, as the type of the chest for the Jews in New York, then we should expect that each of these groups should have the following girth:

Stature.	Calculated Girth.	Observed Girth.	Difference.
Tall.	90.53	88.03	—2.50
Above average.	87.23	86.19	—1.04
Below average.	85.08	84.36	—0.72
Short.	81.48	83.12	+1.64

Which shows that the tall Jews had a girth 2.5 cm. (one inch) shorter than the average; that those of above the average stature had a girth 1.04 cm. shorter than the average, while the Jews

[1] I. I. Pantukhof, "Semitic types," *Proc. Russian Anthropological Society*, St. Petersburg, Vol. II, 1889.

who were short of stature had a girth of 1.64 cm. larger than the average.

This condition is interesting from another standpoint. The average stature of Jewish consumptives has been observed to be superior to that of healthy Jews. The extensive statistics of Snigirew have shown that among Jewish recruits in Russia the relation of stature to girth has been as follows among healthy and consumptive Jews:

	Average for All Jewish Recruits.	Average for Jewish Consumptives.	Difference.
Stature.	1612	1628	—1.54
Girth of chest.	80.18	75.95	—4.23
Relation of girth to stature (percent).	49.68	46.64	—3.04

The figures on this table show that the Jewish consumptive is taller than the normal Jew, but that the girth of his chest is both absolutely and relatively smaller than that of healthy Jews. He is deficient in his "index of vitality" as Goldstein speaks of it.[1] My own observations on Jewish consumptives, as yet unpublished, show that this condition also prevails among the consumptive Jews in New York City. Consumption seems to select its victims preferably among the taller Jews. Judt thinks that this factor, by a natural elimination of the taller Jews, exerts a great influence in reducing their average stature.[2]

The girth of the Jews from various countries varies only slightly as can be seen from the following figures:

Nativity.	Number.	Girth.	Percent of Stature.
Galicia.	191	83.93	51.74
Poland.	173	85.53	52.34
Lithuania.	126	84.93	51.72
Little Russia.	108	85.00	51.30
Roumania.	146	84.41	50.85
Hungary.	121	86.30	52.08
United States.	118	88.09	52.46

[1] *Loc. cit.*

[2] J. M. Judt, "Die Juden als Rasse," Berlin, 1903, p. 85.

The Galician Jews are the narrowest in girth, as they were also the shortest of stature. The most capacious chest on the average, is found among the native Jews, but it is only 52.46 percent of their body height, the same as found among the Polish Jewish immigrants. The Roumanian Jews, who are the tallest immigrants, have the narrowest chest relatively, their girth is only 50.85 percent of their average stature.

CHAPTER IV.

The Head.

The Length of the Head.

The average length of the head, measured with the calipers from the glabella to the most distant point on the occiput, was found to be 188 mm., or 11.43 percent of the body-height. The range of extreme individual variation extended from 169, the shortest, to 208 mm., the longest head, a difference of 39 mm. or 20.74 percent of the average length of the head. This is much smaller than the range of individual extreme variation observed in the case of stature (31 percent). This confirms the accepted dictum that the head is by far less variable than the height of the body, probably because it is less, or not at all, exposed to the influence of external conditions such as climate, nourishment and social status.

Table XVI.

Length of the Head, 1,528 Men.

Length of the Head (in mm.)	Number.	Percent.	Length of the Head (in mm.).	Number.	Percent.
169–170	4	0.26	191–192	186	12.18
171–172	5	0.36	193–194	122	7.98
173–174	10	0.65	195–196	92	6.02
175–176	20	1.31	197–198	62	4.06
177–178	34	2.22	199–200	33	2.16
179–180	90	5.89	201–202	23	1.51
181–182	105	6.87	203–204	7	0.46
183–184	136	8.90	205–206	10	0.65
185–186	204	13.35	207–208	2	0.13
187–188	181	11.85			
189–190	202	13.22		1,528	100.03

The standard deviation was calculated to be 6.129, and the probable error 0.105, both of which are nearly the same as was found for stature. The range of individual variation is shown in the accompanying table (XVI) giving the seriation of the length of the head at intervals of two millimeters. The curve drawn

from these figures shows that there were few individuals with heads less than 176 mm. in length; the largest proportion of persons had heads 185–186 mm. long, and very few persons had heads more than 200 mm. long. At 189–190 mm. the curve appears to rise almost to the same height as at 186 mm., and thus gives the curve the appearance of having a double apex.

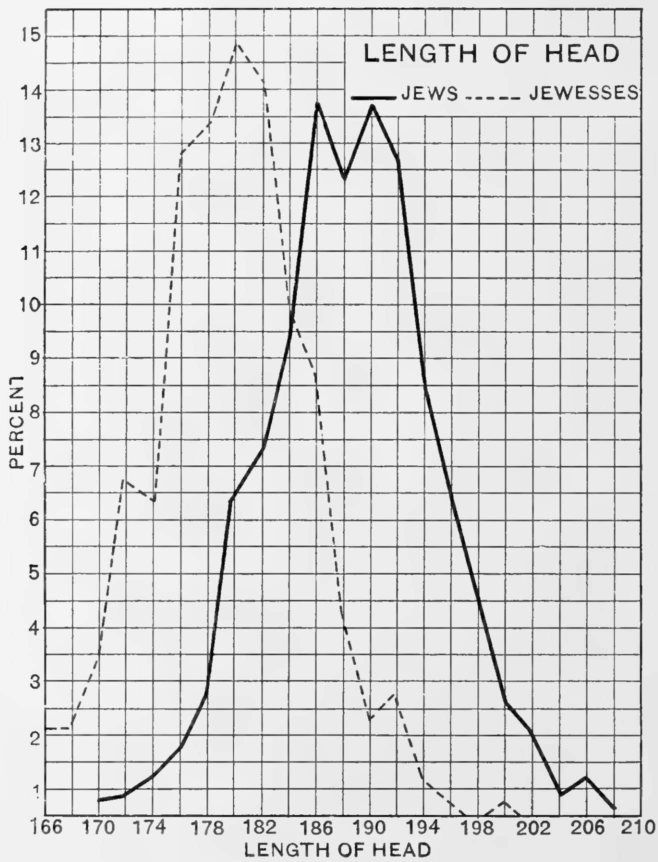

FIG. 4.

This and also the fact that the apex of the curve, representing the largest percentage of individuals, does not correspond to the average length of the head, 188 mm., may give the impression that this is good proof that we deal here with a mixture of two races, one whose average length of the head is 186 mm. and the other with a head 190 mm. long. While this does not exclude racial intermixture, to be sure, still it must be confessed that it does not prove it. The interval between the two maxima, ex-

tends only over four mm., and the apices rise only a little over one percent. Chance variation, individual error of observation may easily produce this variation. Two thirds of all the individuals observed, had heads between 183 and 194 mm. long, which clearly points to single type of head, and not two types. On the other hand all these facts do not justify us in assuming that this is conclusive proof that the Jews are a pure race, free from any intermixture of foreign blood. The races among whom the Jews have lived for centuries in Eastern Europe, and with whom they might have intermarried, if at all, show the same characteristic, and have nearly the same average length of the head, as can be seen from the following figures:[1]

		Average Length of Head.	Authority.
1,056	Great Russians	185 mm.	A. A. Ivanovski.
602	White-Russians	188	A. A. Ivanovski.
611	Little-Russians	184	A. A. Ivanovski.
540	Poles in Russia	186	A. A. Ivanovski.
1,088	Poles in Galicia	180.5	Majer and Kopernicki.
871	Galician Ruthenians	182.3	" "
180	Roumanians	185.76	Pittard.
130	Lithuanians	187	Ivanovski.

The length of the head of these races is seen from these figures to be between 180 and 188 mm. If the usual discrepancies which often occur between the different series of measurements of even a single and homogeneous race are eliminated, we find that the length of the head of the Slav races is about 183 to 187 mm. When we now investigate the anthropological literature of the Jews in Europe we find a remarkable similarity of conditions. As can be seen from the following figures the length of the head of the Jews in Eastern Europe also oscillates around these values.

[1] These figures are taken from the following works: A. A. Ivanowski, "On the Anthropological Composition of the Races of Russia," *Memoirs of the Society of Friends of Natural Science, Anthropology and Ethnography*, Vol. XXII, 1894 (in Russian); Majer and Kopernicki, "Charakterystyka fizyczna ludnosci galicyjskiej," *Zbior viadomosei do antropologii krajowej*, Vol. I, Krakow, 1877; Eugene Pittard, "Anthropologie de la Roumaina," *L'anthropologie*, Vol. XVI, No. I, 1903, pp. 33–58.

	Average Length of Head.	Authority.[1]
200 Polish Jews.................	184 mm.	Elkind
438 Little-Russian Jews	185.4	Talko-Hryncewicz
69 Lithuanian Jews	187.3	" "
413 Galician Jews (Series I)	183	Majer and Kopernicki
(Series II)	186	" "
100 Russian Jews...............	188	Blechman
100 South Russian Jews......	183	Weissenberg
139 White-Russian Jews......	183	Yakowenko
67 Russian Jews...............	187	Dybowsky

It will be observed that the length of the head among the Eastern Europen Jews varies in the various series of measurements, from 183 to 188 mm. As will appear hereafter in places where the non-Jewish population has a longer antero-posterior diameter of the head, the Jews show the same characteristic. It can consequently be stated that if any intermixture of Jews with their neighbors has taken place, we could not expect that this should be shown up in a striking manner in the seriation of the measurements of their heads. The difference is too small to produce any appreciable effect on the average.

From the measurements of the Jewish immigrants in New York City the following are the averages of the length of the head of Jews from various countries. Galician Jews, 186 mm.; Polish, 188 mm.; Lithuanian and White-Russian, 190 mm.; Little-Russian, 188 mm.; Roumanian, 187 mm.; Hungarian, 188 mm.; United States, 190 mm. These figures show that this measurement is larger in the immigrants than in Jews living in eastern Europe. There Majer and Kopernicki found the length of the head to average 183 mm.; in Poland Elkind found in Jews in Warsaw an average of 184 mm.; in Lithuania it was 187 according to Talko-Hryncewicz, and in Little-Russia,

[1] These figures are taken from the following works: A. N. Elkind, "The Jews," *Memoirs of the Society of Friends of Natural Science, Anthropol. and Ethnography*, Vol. XXII, 1902; J. Talko-Hryncewicz, "Charakteristyka fizyczna ludnosci zydowskiej Litwy i Rusi," *Zbior wiad. do antropol. kraj.*, Vol. XVI, 1892; Majer and Kopernicki, *loc. cit.*; B. Blechman, "Ein Beitrag zur Anthropologie der Juden," Inaug.-Dissert. Dorpat, 1882; Weissenberg, "Die südrussischen Juden," *Archiv für Anthropologie*, Vol. XXIII, 1895; M. G. Yakowenko, "Materials for the Anthropology of the Jews," St. Petersburg, 1898 (in Russian); L. Stieda, "Ein Beitrag zur Anthropology der Juden," *Archiv für Anthropol.*, Vol. XIV.

185. This explains the greater dolichocephaly of the immigrant Jews when compared with those who remained at home. It is also noteworthy that this measurement depends to a certain extent on the size of the head of the non-Jewish races of eastern Europe. Thus, in Galicia, the length of the head of the Poles is 180.5 mm. on the average, and the Ruthenians 182.3 mm., being the shortest heads among the races in that region (Majer and Kopernicki) the immigrant Jews from that country measure only 186 mm. on the average; in Russian-Poland, where the indigenous population have longer heads, 186 mm. (Ivanowski); the Jews also have longer heads, 188 mm.; in White-Russia the White-Russians have longer heads, 188 mm. (Ivanowski); the Jewish heads are also longer, 190 mm. The differences are very small, to be sure, but considering the fact that the numbers run so closely, smaller where the length of the head

Table XVII.

Length of the Head in 1,528 Jews According to Nativity.

Length of the head (in mm.)	Galicia.	Poland	Lithuania and White-Russia	Little-Russia	Roumania.	Hungary.	United States.
169–170	0.98	—	—	—	—	—	0.80
171–172	0.32	0.63	—	0.45	—	0.72	—
173–174	0.98	0.95	0.36	0.91	—	0.72	—
175–176	1.64	0.63	0.73	2.28	3.33	0.72	—
177–178	2.63	2.54	0.36	0.91	4.00	5.00	1.61
179–180	8.19	5.11	5.46	4.57	7.33	7.14	2.42
181–182	10.82	5.11	2.54	8.22	9.33	7.14	5.65
183–184	10.49	7.93	6.91	7.31	10.67	11.43	9.68
185–186	16.73	12.68	17.82	12.79	12.67	8.57	4.03
187–188	11.15	12.38	8.37	14.16	12.67	13.57	12.90
189–190	13.11	11.11	14.55	11.88	14.00	12.86	17.74
191–192	10.49	16.51	11.63	11.42	10.67	10.71	11.29
193–194	4.59	7.61	9.44	11.42	6.67	8.57	8.87
195–196	3.61	7.93	10.18	5.48	3.33	2.14	6.45
197–198	1.64	3.81	4.73	2.28	4.00	6.43	9.68
199–200	0.65	2.22	4.00	1.82	0.67	2.86	3.23
201–202	0.98	1.59	1.82	1.82	—	1.43	3.23
203–204	0.32	0.32	0.36	0.91	—	—	1.61
205–206	0.65	0.95	0.36	0.91	0.67	—	0.80
207–208	—	—	0.36	0.45	—	—	—
No. observed.	305	315	275	219	150	140	124
Average.	186	188	190	188	187	188	190
Maximum.	206	206	207	208	205	201	205
Minimum.	169	171	173	171	175	171	170

of the non-Jewish races have smaller heads, and larger where the non-Jewish races have larger heads, it is worthy of being mentioned. This is of importance also because many of the other somatic characteristics of the Jews, as stature, head-form, etc., follow the same rule.

The relation of stature to the size of head is shown in the following table:

Stature.	Number Observed.	Length of Head.	Percent of Stature	Calculated Length of Head.	Difference.
Short	356	186	11.91	178	+8
Below the average	460	187	11.50	186	+1
Above the average	420	188	11.43	191	−3
Tall	292	190	10.95	198	−8
Total	1,528	188	11.43	—	—

It will be observed from these figures that with the increase of stature the size of the head does not increase proportionally, although it increases absolutely. Thus, while the length of the head of the tall persons was 4 mm. longer than that of the short persons, but in the former it was 10.95 per cent of the body-height, as against 11.91 percent in the latter. If we take the average length of the head as a standard, and consider that the normal length of the Jew's head is 11.43 percent of his stature, we should expect that the short people should have heads 178 mm. long; but empirically we find that it is 8 mm. larger than expected — 186. On the other hand, the tall persons would on the same basis be expected to have a length of the head of 198 mm., but empirically it is seen to be 8 mm. shorter — 190 mm. All this again shows that with the increase of stature, the various parts of the body increase also, but only absolutely, and that relatively to the body-height it decreases.

The Length of the Head of the Women.

The average length of the head of the 435 Jewesses was 179 mm. — 9 mm. shorter than that of the Jews, or 95.21 percent of the length of the head found in men. When it is considered in connection with the shorter stature of the women, it is seen

that their head is not at all smaller than that of the men. In men it was found that the length of the head amounts to 11.43 percent of the body-height, and in the women it is seen to be 11 percent — almost the same. The longest head encountered among the women was 199 mm., the shortest 159 mm., a difference of 40 mm., or 22.34 percent of the average, and larger than that found for the men. The standard deviation is 6.085 and the probable error 0.193, both about the same found for the men.

The seriation shown in Table XVIII, and its graphic repre-

TABLE XVIII.

LENGTH OF THE HEAD OF 435 JEWESSES.

Length of the Head (in mm.).	Number.	Percent.	Length of the Head (in mm.).	Number.	Percent.
159–160	2	0.46	181–182	59	13.57
161–162	—	—	183–184	41	9.43
163–164	3	0.69	185–186	36	8.28
165–166	7	1.61	187–188	17	3.91
167–168	7	1.61	189–190	8	1.84
169–170	13	2.99	191–192	10	2.29
171–172	27	6.21	193–194	3	0.69
173–174	26	5.95	195–196	1	0.23
175–176	54	12.39	197–198	—	—
177–178	56	12.88	199–200	1	0.23
179–180	64	14.71	Total.	435	99.97

sentation on diagram 4, show nothing of significance, excepting that the curve is smooth and its apex occurs at 179–180 mm., the median length, where 14.71 percent of all the observations are found.

From Table XIX is seen that the average length of the head of the immigrant Jewesses is larger than that of Jewesses who remained at home. Excepting those from Galicia, who measured exactly the same as the Jewesses measured by Majer and Kopernicki in Galicia, the Polish Jewesses averaged 181 mm., as against only 177 mm. in Warsaw; the Little-Russian Jewesses were found to have an average length of the head of 180 in New York City, and only 177 in their native land (Talko-Hryncewicz). This corresponds to the facts observed while considering the same measurement in men.

Table XIX.

Length of the Head in 435 Jewesses, According to Nativity.

Length of the Head (in mm.)	Galicia.	Poland.	Lithuania and White-Russia	Little-Russia.	Roumania.	Hungary.
159–160	—	1.79	—	1.35	—	—
161–162	—	—	—	—	—	—
163–164	1.64	—	1.00	—	—	—
165–166	2.46	—	1.00	2.70	—	—
167–168	3.28	—	2.00	—	—	2.56
169–170	1.64	3.57	2.00	1.35	6.82	7.69
171–172	8.20	3.57	6.00	1.35	4.55	15.38
173–174	6.56	7.14	5.00	6.76	—	10.26
175–176	11.48	8.93	12.00	13.51	22.73	7.69
177–178	18.03	14.29	9.00	9.46	15.91	7.69
179–180	15.57	14.29	16.00	13.51	15.91	10.26
181–182	9.00	10.71	20.00	20.27	6.82	10.26
183–184	7.38	12.50	7.00	10.81	9.09	15.38
185–186	6.56	10.71	8.00	9.46	13.64	2.56
187–188	2.46	5.36	6.00	5.41	—	2.56
189–190	2 46	1.79	1.00	—	2.27	5.13
191–192	3.28	3.57	2.00	1.35	—	2.56
193–194	—	1.79	1 00	1.35	—	—
195–196	—	—	1.00	—	—	—
197–198	—	—	—	—	2.27	—
199–200	—	—	—	1.35	—	—
No. observed.	122	56	100	74	44	39
Average.	178	181	179	180	179	178
Maximum.	192	193	196	199	197	191
Minimum.	163	160	163	160	169	167

The rule observed in men that the antero-posterior diameter of the head of the Jews depends on that of the non-Jewish races in the same country is not evident among the Jewesses.

Width of the Head.

The width of the head was obtained by searching with the points of the calipers along the temples, over the ears and somewhat posteriorly. The average for the 1,528 men was 154.4 mm. — 9.37 percent of the body-height. The maximum was 174 mm., and the minimum 130 mm., a difference of 44 mm., or 28.57 percent of the average, which is larger than that observed for the length of the head — 20.74 percent. This is due to the fact that the individual who had a head of 130 mm. in width was quite an exception. He was an Hungarian by birth and his head measured 198 mm. in length, thus giving a ce-

phalic index of 65.66. He presented many signs of rickets in early life. Excluding this individual, we find that the extreme individual variation extends over 39 mm. (135 the maximum, and 174 the minimum), or 25.32 of the average, which is also larger than that found for the length of the head. This tends to indicate that the width of the head is not as stable a trait as is sometimes considered, and that its length is more valuable as a measure of somatic characteristic. The standard deviation was 5.482, and the probable error 0.9443.

The seriation of the width of the head is given in the accompanying Table XX, and in diagram 15, a curve is drawn from these figures. This curve appears smooth, pointing at 154 mm., which corresponds to the general average width. Over 80 percent of all observations have had heads from 147 to 160 mm. wide, a variation of only 13 mm.

Table XX.

Width of the Head of 1,528 Jews.

Width of the Head (in mm.).	Number.	Percent.	Width of the Head (in mm.).	Number.	Percent.
129–130	1	0.07	153–154	234	15.32
131–132	—	—	155–156	231	15.12
133–134	—	—	157–158	192	12.56
135–136	1	0.07	159–160	131	8.57
137–138	3	0.21	161–162	65	4.25
139–140	8	0.52	163–164	55	3.60
141–142	16	1.04	165–166	28	1.83
143–144	33	2.16	167–168	4	0.26
145–146	64	4.19	169–170	2	0.13
147–148	96	6.28	171–172	2	0.13
149–150	155	10.14	173–174	2	0.13
151–152	205	13.41	Total.	1,528	99.99

Taller men have relatively narrower heads than shorter men, as can be seen from the following table :

Stature.	Number Observed.	Width of Head.	Percent of Stature.	Calculated Width of Head	Difference.
Short	356	153	9.80	146	+7
Below the average	460	154	9.37	152	+2
Above the average.	420	154	9.37	156	—2
Tall	292	156	8.99	162	—6
	1,528	154	9.37	—	—

It is seen that while the absolute width of the head of the tall persons was on the average three mm. larger than that of the short people, they were nevertheless relatively narrower. The latters' heads were on the average 9.8 percent of their

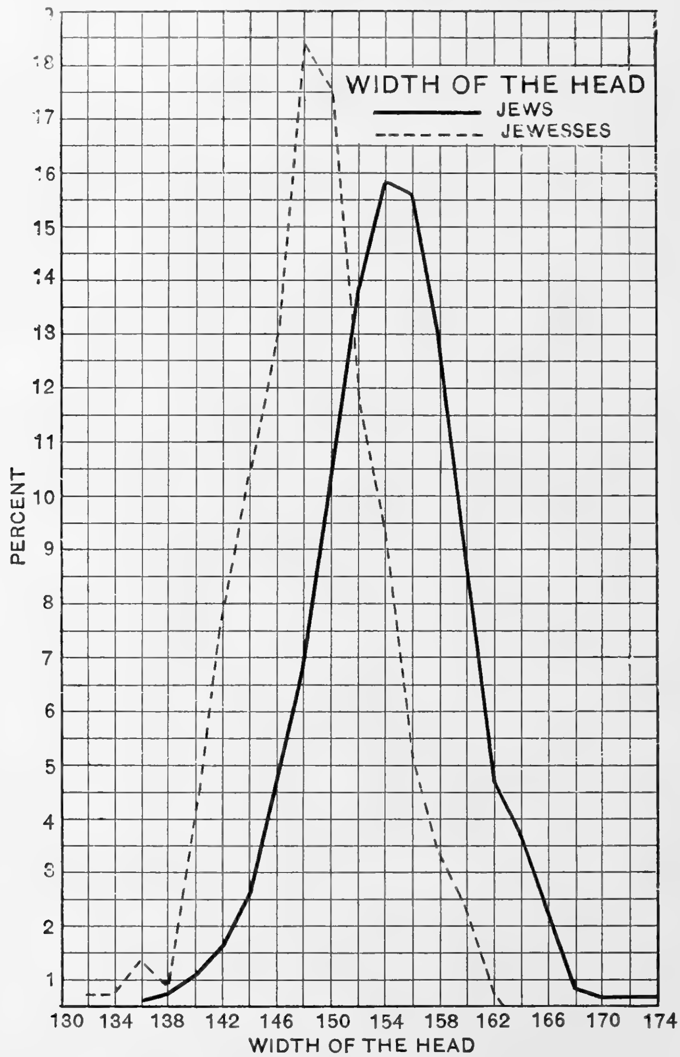

FIG. 5.

body height, while in the former the percentage was only 8.99, being 6 mm. shorter than the average length and the short persons had heads 7 mm. wider than the average width would indicate.

The average width of the head of the Jews according to their

nativity is about the same in each group, ranging from 153 mm. in the Roumanian Jews, 154 in the Polish and Lithuanian Jews, to 155 mm. in all the other groups. When compared with Jews who were measured in eastern Europe, the immigrants have somewhat wider heads, but the differences are very small, from one to three mm. There is no evidence in these figures of a correspondence of the width of the head of the Jews with that of the Gentiles of the country of their birth. In Galicia the width of the head of the Poles was found to be 152 mm. and of the Ruthenians 153 mm., that of the Jews is 155 mm.; in Russian Poland Elkind found the average width of the head of the Poles in Warsaw to be 150 mm. on the average, and that of the Jews is 154 mm.; the Letto-Lithuanians and the White-Rus-

TABLE XXI.

WIDTH OF THE HEAD IN 1,528 JEWS ACCORDING TO NATIVITY.

Length of Head (in mm).	Galicia.	Poland.	Lithuania and White-Russia.	Little-Russia.	Roumania.	Hungary.	United States.
120–130	—	—	—	—	—	0.71	—
131–132	—	—	—	—	—	—	—
133–134	—	—	—	—	—	—	—
135–136	—	—	—	—	—	—	0.80
137–138	0.32	—	0.36	0.45	—	—	—
139–140	0.32	0.63	0.73	0.45	—	0.71	0.80
141–142	0.65	2.22	1.82	0.45	—	—	0.80
143–144	2.63	2.22	4.36	0.91	2.00	—	0.80
145–146	7.87	2.22	4.73	3.20	4.00	3.57	1.61
147–148	5.90	3.17	9.09	10.05	2.00	7.14	6.45
149–150	7.87	12.70	9.82	6.85	16.00	8.57	11.29
151–152	15.41	13.33	9.82	15.98	12.67	12.86	13.72
153–154	14.10	13.96	17.09	14.16	16.67	12.14	21.78
155–156	13.12	17.46	16.37	13.70	14.67	17.86	11.29
157–158	11.15	11.75	13.82	13.70	13.33	15.71	9.68
159–160	8.20	10.79	4.00	8.67	8.67	7.86	14.51
161–162	4.92	4.44	2.54	4.57	7.33	4.30	1.61
163–164	3.61	2.54	3.64	4.57	2.00	5.00	4.84
165–166	2.95	1.90	1.09	1.82	—	2.86	—
167–168	0.32	—	0.73	—	—	0.71	—
169–170	—	0.32	—	0.45	—	—	—
171–172	0.32	0.32	—	—	—	—	—
173–174	0.32	—	—	—	0.67	—	—
No. observed.	305	315	275	219	150	140	124
Average.	155	154	154	155	153	155	154
Maximum.	173	171	168	170	174	168	164
Minimum.	138	139	138	138	143	130	135

sians have an average width of 151 mm. (Talko-Hryncewicz), and the Jews from that coun'ry 154 mm.; in Little Russia the indigenous population, according to Talko-Hryncewicz, have an average width of the head of 153 mm., and the Jews from that country average 155 mm.; finally the Roumanians measure 154 on the average (Pittard) and the Jews 153 mm. There is thus not evident any relation between the measurement of the width of the head of the Jews and that of the indigenous races of eastern Europe among which they have lived. The differences are almost insignificant, being less than the chances of error would lead one to expect. There is however a striking similarity in the average values as a whole. The fluctuations in these values is among the Gentile races from 152 to 154 mm., and among the Jews from 153 to 155 mm., practically the same. It cannot be expected that any influence one group may have had on the other should be evident from a study of the width of the head, because the values are practically uniform in magnitude.

TABLE XXII.

WIDTH OF THE HEAD OF 435 JEWESSES.

Width of the head (in mm.).	Number	Percent.	Width of the head (in mm.).	Number.	Percent.
131–132	1	0.23	151–152	50	11.49
133–134	1	0.23	153–154	38	8.74
135–136	4	0.92	155–156	21	4.83
137–138	2	0.46	157–158	12	2.76
139–140	16	3.68	159–159	8	1.84
141–142	32	7.35	161–162	1	0.23
143–144	43	9.89	163–164	—	—
145–146	53	12.18	165–166	1	0.23
147–148	78	17.93			
149–150	74	17.01	Total.	435	100.00

The width of the head of the women was 149 mm. on the average, or 9.77 percent of their average stature. The maximum width was 165, and the minimum, 131 mm., a difference of 24 mm. or 16.1 percent of the average, which is much smaller than that of the men. The standard deviation was 5.015; the probable error 0.162, both about the same as in men, considering that the number of women measured was much smaller than

men. A glance at Table XXII and the curve on diagram 5 shows again the phenomenon observed when the length of the head was considered. The apex of the curve for the women rises much higher than that for the men — nearly 18 percent had heads 147–148 mm. wide, and 17 percent 149–150 mm. The curve in general is much narrower, and quite smooth. 77 percent of all observations lie within a range of 10 mm. — between 143 and 154 mm. This of course points to a great uniformity of type.

Table XXIII.

Width of Head in 435 Jewesses According to Nativity.

Width of the Head (in mm.).	Galicia.	Poland.	Lithuania. and White-Russia.	Little-Russia.	Roumania	Hungary.
131–132	0.82	—	—	—	—	—
133–134	—	—	1.00	—	—	—
135–136	1.64	1.79	—	1.35	—	—
137–138	0.82	—	—	1.35	—	—
139–140	2.46	—	3.00	10.81	4.55	—
141–142	7.38	8.93	9.00	8.11	—	7.69
143–144	4.92	19.64	9.00	9.46	13.64	10.26
145–146	8.20	8.93	16.00	12.16	9.09	23.08
147–148	13.93	25.00	17.00	17.57	22.73	17.95
149–150	22.95	10.71	19.00	12.16	15.91	12.82
151–152	10.66	10.71	14.00	8.11	18.18	7.69
153–154	12.30	5.36	4.00	10.81	9.09	10.26
155–156	6.56	1.79	6.00	4.05	2.27	5.13
157–158	4.92	5.36	1.00	2.70	—	—
159–160	1.64	1.79	1.00	1.35	4.55	2.56
161–162	—	—	—	—	—	2.56
163–164	—	—	—	—	—	—
165–166	0.82	—	—	—	—	—
No. observed.	122	56	100	74	44	39
Average width.	151	148	149	148	149	148
Maximum.	165	159	159	159	160	161
Minimum.	136	136	134	136	139	142

According to their nativity, the Jewesses show an almost uniform width of the head, as is seen from Table XXIII. The immigrant Jewesses have on the average wider heads than the Jewesses in eastern Europe. Thus, the Jewesses in Galicia average 143 mm. (Majer and Kopernicki) in width, while the immigrant Jewesses from that country measured 151 mm.; the Polish Jewesses in the United States average in the width of the

head 148 mm., while in Warsaw this measurement was found only 146 mm. (Elkind); the Lithuanian and White-Russian Jewesses in New York had an average width of the head of 149 mm. and in their native country Yakowenko has found this measurement to amount to 144 mm.; and in Little-Russia the average was 145 mm. (Talko-Hryncewicz) as against 148 mm. of immigrant Jewesses from that country.

Compared with the non-Jewish women in these countries in eastern Europe it is seen that there is practically no difference between the two. The Gentile women measure as follows: White-Russian 145 mm. (Talko-Hryncewicz), Little-Russian 148 mm., Polish 146 mm. (Elkind), Letto-Lithuanian 145 mm., Ruthenians 147 mm (Majer and Kopernicki). It is thus seen to be quite uniform, and this characteristic is shared by the Jewesses.

The Cephalic Index.

The average cephalic index was obtained by multiplying the average width of the head by 100, and dividing the product by the average length, thus:

$$100 \times \frac{154}{188} = 81.91 = \text{Cephalic index.}$$

The minimum was 65.66, and the maximum 94.76, showing an extreme individual variation of 29 units, or 35 percent, of the average index. Excluding the individual with an index of 65.66 as pathological, there still remains a range of extreme variation of 24 units, or 29 percent of the average. It will also be observed that the deviation from the average was much larger toward the minimum — 20.73 percent of the average (65–82), while the maximum was only 14.63 percent distant from the average. This tends to indicate a greater tendency to dolichocephaly.

The standard deviation was 3.176, and the probable error 0.05477, much smaller than that found in the case of stature and the length and width of the head. Between ± of the standard deviation, *i. e.*, between the cephalic index of 78 and 85, were 1,243 individuals — 81.34 percent of all observations were

within these limits. The significance of this is more apparent when we consider the probable error, which was only 0.054. It shows that there is an even chance that when we should obtain another series of 1,528 Jews in New York City we shall find their average cephalic index within the limits of ± of the probable error — 81.85 and 81.96. The chances are four to one that it will be within twice these limits, and nineteen to one that it will lie within thrice these limits, *i. e.*, between 81.748 and 82.072. The head-form is thus shown to have a very small range of variability, and the average determined in this series is quite close to the true or ideal average. This confirms again the conclusion that the cephalic index is a very stable racial trait.

Classifying the figures according to Deniker's scheme, we find the following distribution :

	Number.	Percent.
Hyperdolichocephalic (less than 76)	44	2.89
Dolichocephalic (76 and 77)	112	7.36
Subdolichocephalic (78 and 79)	236	15.51
Mesocephalic (80 and 81)	394	25.78
Subbrachycephalic (82 and 83)	367	24.01
Brachycephalic (84 and 85)	246	15.97
Hyperbrachycephalic (86 and more)	129	8.48
	1,528	100.00

This shows that the type of the Jewish head is mesocephalic. Fifty percent of individuals had a cephalic index varying between the limits of four units, 80 to 83 inclusive; over eighty percent varied only between the limits of eight units, 78 to 85. This of course, points to homogeneity of cranial type.

This apparent uniformity of cranial type is displayed to a yet better advantage when the seriation of the cephalic index is observed in which each individual index is given with the percentage of frequency of persons who had a given index, as has been done in Table XXIV. The curve plotted on a scale from these figures on diagram 6 shows this in a graphic form. It will be seen that the cephalic index of 65 stands alone. It may be disregarded because it is a manifestation of rickets in the early years in its possessor. One individual had a cephalic index of 70, not one with 71. Only at 72 does the real series begin :

Table XXIV.

Cephalic Index of 1,528 Jews.

Cephalic Index.	Number.	Percent.	Cephalic Index.	Number.	Percent.
65	1	0.07	83	166	10.86
70	1	0.07	84	138	8.90
71	—	—	85	108	7.07
72	1	0.07	86	66	4.32
73	4	0.26	87	22	1.44
74	17	1.11	88	28	1.83
75	20	1.31	89	4	0.26
76	40	2.62	90	1	0.07
77	72	4.74	91	3	0.21
78	111	7.33	92	3	0.21
79	125	8.18	93	1	0.07
80	194	12.69	94	1	0.07
81	200	13.09			
82	201	13.15	Total.	1,528	100.00

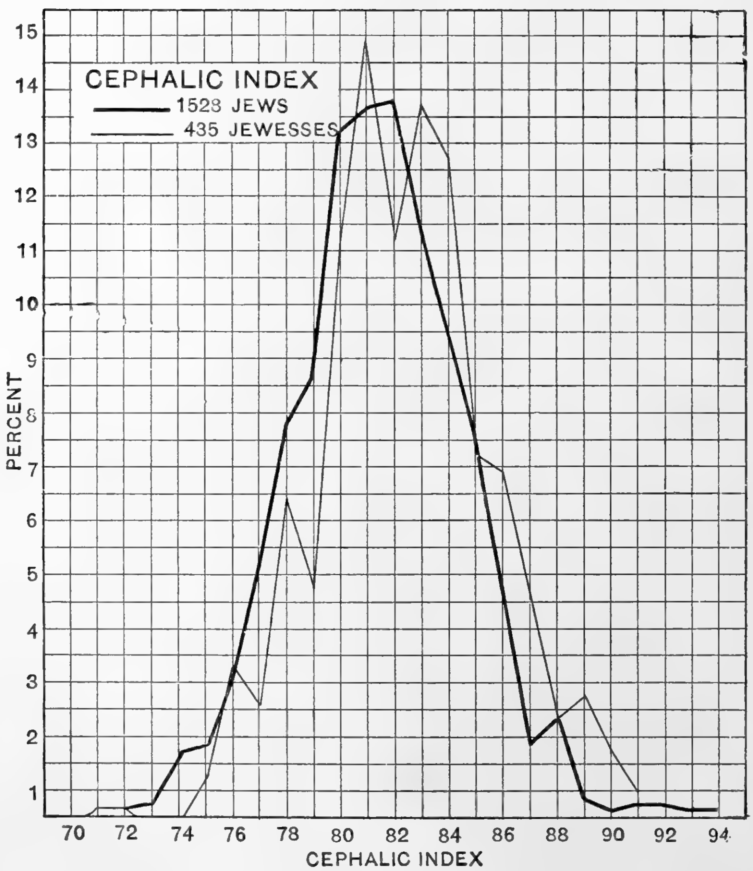

Fig 6

4 persons (0.26 percent) with an index of 73, and then the curve begins to rise steadily till the index of 81 is reached. At this point the number observed persons is over 13 percent. The curve now begins to descend steadily, with a slight rise at 88 which is of no special significance — it may be attributed to chance variation.

This curve apparently proving uniformity of the cranial type of the Jews of eastern Europe, appears rather striking and peculiar. Appearing as it does, together with a wide range of extreme individual variation. In order to test our own results we have decided to compare this material with that of other investigators. We have for this purpose obtained measurements of 1,113 Jews from the literature on the anthropology of these people in eastern Europe. Only such statistics were taken as were reported in a form suitable for comparison with our own figures. Such were found in the works of Yakowenko (139 Lithuanian Jews), Elkind (200 Polish Jews). Talko-Hryncewicz (507 Jews in Lithuania and Little-Russia), Weissenberg (100 South-Russian Jews), Stieda (67 Jews in Minsk-Russia), and Blechman (100 Jews in Russia). Classifying these figures as we did our own we find :

Cranial Type.	Jews in Europe.	Jews in U. S.	Both Series Combined.
Hyperdolichocephalic	1.78%	2.89%	2.42%
Dolichocephalic	4.76	7.36	6.24
Subdolichocephalic	12.58	15.51	14.23
Mesocephalic	22.73	25.78	24.50
Subbrachycephalic	25.42	24.01	24.61
Brachycephalic	18.69	15.97	17.19
Hyperbrachycephalic	14.03	8.47	10.81

From these figures it is seen again that fifty percent of all observations lie within the limits of four units, in each of the three series, and eighty percent within the limits of eight units. The seriation of these measurements as was done in Table XXV is yet more striking. In both series the curve is quite smooth, the slight indentations can be explained as caused by errors of observation and calculation, and are always expected to occur, no matter how careful the observer may be. The indentation at

the cephalic index of 81 in the curve for the 1,113 Jews in Eastern European Jews, may be explained by this or by chance variation. This is probably also the cause of the elevation of the curve for all the 2,641 Jews at the index of 80.

TABLE XXV.

CEPHALIC INDEX IN 1,113 JEWS IN EASTERN EUROPE.

Cephalic Index.	Number.	Percent.	Cephalic Index.	Number.	Percent.
70	1	0.09	84	112	10.06
71	—	—	85	96	8.63
72	1	0.09	86	72	6.47
73	5	0.44	87	34	3.06
74	4	0.36	88	22	1.97
75	9	0.81	89	11	1.00
76	16	1.44	90	7	0.63
77	37	3.32	91	4	0.36
78	52	4.67	92	2	0.18
79	88	7.91	93	3	0.27
80	126	11.32	94	—	—
81	127	11.41	95	1	0.09
82	155	13.92			
83	128	11.50	Total.	1,113	100.00

Before proceeding to discuss these curves as a test of the purity of race we want to point out one peculiar feature of these two series of observations. It will be seen that the immigrant Jews in New York have 10.25 percent of persons with heads of the dolichocephalic type (cephalic index less than 78), while the Jews in Eastern Europe have only 6.54 percent of such individuals. On the other hand, 32.72 percent of Jews in Eastern Europe have brachycephalic heads (cephalic index 84 and more) while those who have left Europe and emigrated to the United States have only 24.45 percent of people with this cranial type. The difference is more striking when observed on diagram 7. The curve for the Jews in New York City is seen toward the left, while the one for Jews in Eastern Europe is moved to the right. All this tends to show that the immigrant Jews are more longheaded than the average of the people whom they leave behind in their native county. Lapouge, Ammon, Ripley and others will see in this a further proof for the theory that great cities serve, for some obscure reason, as an attraction to

long-headed humanity.[1] How far the longheadedness of the Jewish immigrants to the United States as compared with the Jews in Eastern Europe, is due to the same conditions which are operative in Western Europe, we are not in a position to state. We

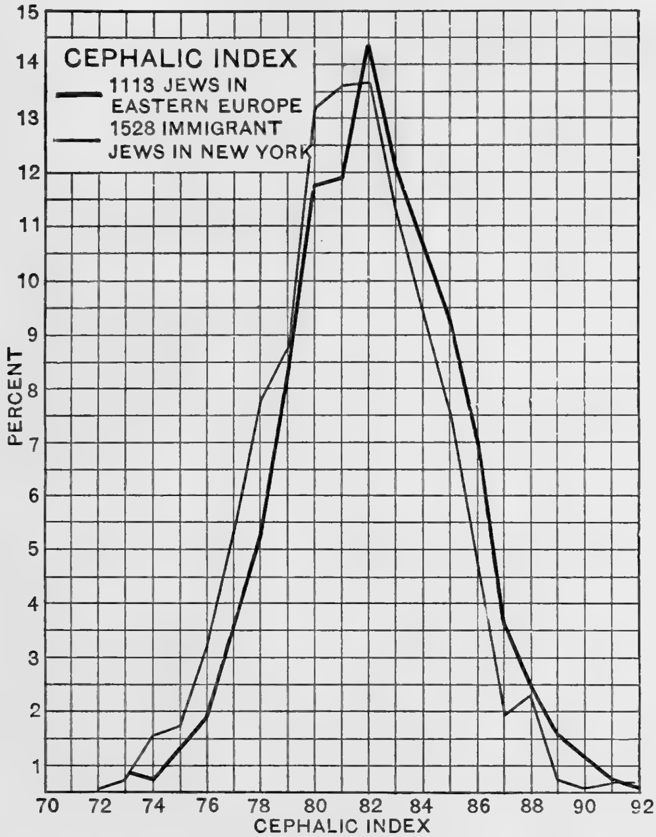

FIG. 7.

merely note the fact, and can add that from Jacobs' observations in London, the same appears to be the case with the Jews there.[2]

A combination of both series of observations, those of Elkind, Talko-Hryncewicz, Blechman, Weissenberg, etc., and those of our own, as we have done in Table XXVI, and the curve drawn from these figures representing measurements of 2641 Jewish

[1] See Otto Ammon, "Zur Anthropologie der Badener," pp. 431 and 614; Wm. Z. Ripley, "The Races of Europe," chapter XX.

[2] Joseph Jacobs, "On the comparative anthropometry of English Jews," *Journal Anthropological Institute*, XIX, 1890, pp. 76–88.

heads, depict yet more graphically the homogeneity of the cranial type of the Eastern European Jews. This homogeneity may easily deceive us into believing it to be the best proof of the freedom of the Jews from admixture of foreign blood. This in fact was the opinion we entertained in 1902, when discussing the same problem,[1] but a close study of the anthropology of the races and peoples in Eastern Europe among whom the Jews have lived for centuries, has materially altered our opinion.

These Jews come from the parts of Russia known as Lithuania, White-Russia, Little Russia and Poland ; and also from Austrian Galicia, Hungary and Roumania. A careful study of the head-form of the indigenous populations of these countries reveals the following remarkable fact : their head-form is more homogeneous than that of the population of any other part of Europe. "The perfect monotony and uniformity of environment of the Russian people" says Ripley, "is most clearly expressed anthropologically in their head-form . . . a moment's consideration of our map shows at once a great similarity of headform prevailing all over Europe from the Carpathian mountains east and north. *The cephalic index oscillates but two or three points above a center of 82.* . . . Our widest variation in Russia is about five units.[2]

It is safe to assume that if any non-Jewish blood has been infused into the veins of the Eastern European Jews during the last thousand years, must have come from exactly the races and peoples inhabiting just this region of Europe. A close examination of the map ingeniously prepared by Ripley[3] shows graphically that the cephalic index of these peoples is about the same as that of the Jews we are considering. Any slight differences that occur in some places, are also to be observed in the Jews from these countries. Wherever there is an increase in the width of the head of the native races, as for instance in Galicia, the same is to be observed in the Jews coming from these countries. The difference may be ever so small, it is still

[1] See "Physical Anthropology of the Jews," I, Cephalic Index, *American Anthropologist,* N. S., IV, pp. 684–706.

[2] Wm. Z. Ripley, "The Races of Europe," pp. 341–342.

[3] *Ibid.*, p. 340.

perceptible to the calipers when measurements are taken on the Jews.

The cephalic index is considered by many anthropologists a primary test of race. At the present state of our knowledge we are not aware that it is influenced by any external conditions and environment. Neither climate, nor altitude, nor any artificial or social selection, social or economic conditions are known to have any effect on the shape of the head. Wherever any differences in headform have been found, anthropologists have always looked for its cause in the intermixture of races. But can we accept uniformity of cranial type, even such striking uniformity as is displayed by the Eastern European Jews when studied *en masse* as a proof of their racial purity and the absence of any non-Jewish blood in their veins?

In order that we may answer this question intelligently, we have collected measurements taken by European observers on the various Slav races inhabiting the countries in which these Jews have lived for nearly 1,000 years. For Poland, Elkind's work has been used; Talko-Hryncewicz's works have been drawn upon for data on the Letto-Lithuanians, Little-Russians, and White-Russians; for the Roumanians figures have been taken from Pittard's recent study of this people. We have thus collected measurements of 2,906 non-Jewish inhabitants of Eastern Europe, and have compared them with the Jews under consideration.

A glance at Table XXVI and the accompanying diagram, 8, reveals the following remarkable features: The course of both curves is about the same, excepting that the curve representing the Jews appears to be tending to display more dolichocephalic heads — it is more toward the left. The curve for the Slavs shows a small elevation at the index of 80 and an indentation at 81. That this is not an indication of any particular racial element can be concluded by considering the fact that the interval between the two apices is only one unit — 81; and the difference between the proportion of the indices is very small. There appears to have been a few more individuals with an index of 80, than might be expected theoretically, and a few less with the

XXVI.

Cephalic Index of Jews and Non-Jews in Eastern Europe.

Cephalic Index.	Jews.		Non-Jews.		Jews and Non-Jews.	
	Number.	Percent.	Number.	Percent.	Number.	Percent.
65	1	0.04	—	—	1	0.04
70	2	0.07	—	—	2	0.03
71	—	—	7	0.24	7	0.11
72	2	0.07	2	0.07	4	0.07
73	9	0.36	9	0.31	18	0.32
74	21	0.79	20	0.68	41	0.74
75	29	1.09	27	0.93	56	1.01
76	56	2.12	64	2.20	120	2.16
77	109	4.12	100	3.44	209	3.76
78	163	6.17	161	5.54	324	5.84
79	213	8 06	193	6.64	406	7.31
80	320	12.12	313	10.77	633	11.59
81	327	12.38	249	8.57	576	10.39
82	356	13.48	334	11.49	690	12.43
83	294	11.13	335	11.53	629	11.33
84	250	9.46	306	10.53	556	10.02
85	204	7.73	246	8.47	450	8.11
86	138	5.22	193	6.64	331	5.96
87	56	2.12	134	4.61	190	3.44
88	50	1.89	86	2.96	136	2.47
89	15	0.57	61	2.10	76	1.26
90	8	0.31	33	1.14	41	0.74
91	7	0.27	15	0.52	22	0.39
92	5	0.19	6	0.21	11	0.19
93	4	0.16	4	0.13	8	0.14
94	1	0.04	5	0.17	6	0.10
95	1	0.04	3	0.10	4	0.07
Total.	2,641	100.00	2,906	99.99	5,547	100.00

index 81. The same holds good for the curve representing both Jews and Slavs on diagram 8. Here the curve runs quite a smooth course. The apex corresponds to the average index, and at both sides of the apex the curve descends steadily — the proportion of persons with given indices decreases regularly the further we get away from the average cephalic index. The largest proportion of persons had an index of 82 — the average cephalic index, and on both sides of this apex the curve runs steadily down. There appears to be a good symmetrical and harmonious arrangement of the curve on both sides. In fact there are all the evidences to lead us into believing that we deal here with a single, homogeneous and pure race. But, as we

know, there is here represented more than one half a dozen races, each of which taken by itself can not be considered free from foreign elements to any extent.

The head-form of the Eastern European Jews, when studied *en masse*, is consequently not a safe criterion as to their racial purity. Even if they had intermarried, clandestinely or openly, in centuries bygone or in modern times, with their Slavic neigh-

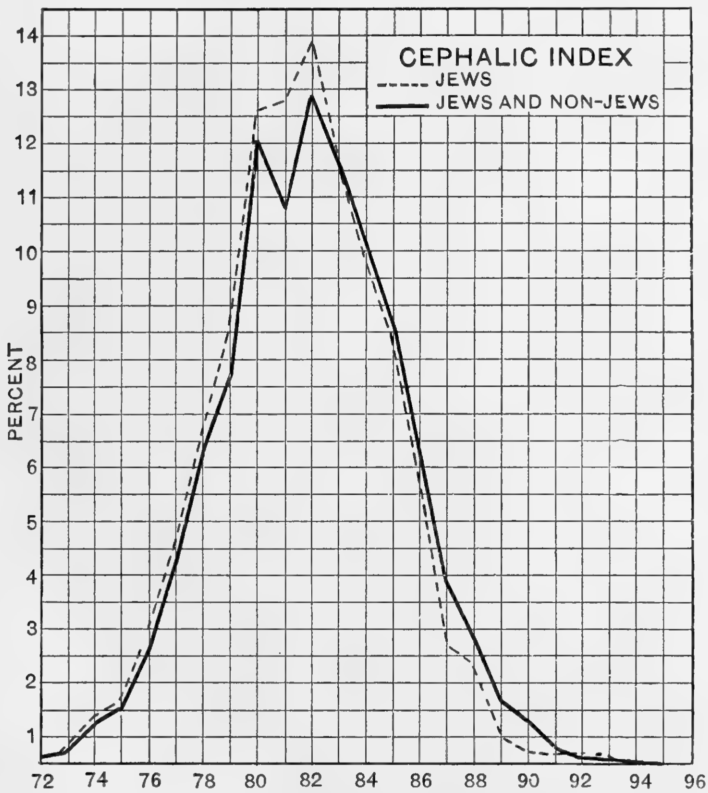

FIG. 8.

bors in Eastern Europe, we can not expect that the foreign blood thus infused should be evident in the study of their cranial type. The differences, if any are to be discerned, are too small to be felt by the calipers and tape to an extent as to show any characteristics in the cephalic index.

It may therefore be presumed that the only method which promises to give more or less satisfactory results is the application of the comparative study of the head-form of the Jews with

that of the races among which they have lived for a longer time in given localities. If we find that the shape of the head is the same in every country, notwithstanding the differences displayed in this regard by the non-Jewish races in these localities, then we may of course see in this a good argument in favor of the purity of the race, and the absence of any serious intermixture of foreign blood. But if, on the other hand, we find that wherever the head of the non-Jewish population is broader or longer, the Jews also display this characteristic; then the only cause to be assigned for this phenomenon is, at the present state of our knowledge, the admixture of foreign racial elements.

Table XXVII.

Cephalic Index in 1,528 Jews According to Their Nativity.

Cephalic Index.	Galicia.	Poland.	Lithuania and White-Russia.	Little-Russia.	Roumania.	Hungary.	United States.
65	—	—	—	—	—	0.71	—
68	—	—	—	0.45	—	—	—
70	—	0.32	—	—	—	—	—
71	—	—	—	—	—	—	—
72	—	0.32	—	—	—	—	—
73	0.32	0.63	0.36	—	—	—	—
74	0.32	1.59	1.45	1.37	—	0.71	2.42
75	0.98	0.95	3.28	1.37	—	0.71	0.80
76	0.98	3.49	4.36	2.74	1.33	2.14	2.42
77	3.93	4.78	8.00	2.28	2.67	1.43	9.68
78	4.26	5.08	10.91	7.77	6.67	5.00	14.51
79	4.92	8.89	10.91	8.67	7.33	7.14	9.68
80	14.10	13.33	14.91	10.05	13.33	11.43	7.26
81	13.77	9.21	12.36	14.61	15.33	12.86	18.55
82	14.43	14.92	9.45	19.63	9.33	10.72	9.68
83	12.46	11.75	8.00	9.60	10.00	17.85	5.65
84	8.20	10.47	8.73	7.31	9.33	11.43	8.07
85	8.20	7.30	2.54	6.40	12.00	9.29	6.45
86	5.25	2.86	3.28	5.93	6.00	3.57	4.03
87	2.63	0.95	0.73	1.37	3.33	—	0.80
88	3.93	1.90	0.73	0.45	2.00	2.86	—
89	0.32	0.32	—	—	0.67	0.71	—
90	—	0.32	—	—	—	—	—
91	—	—	—	—	0.67	1.43	—
92	0.98	—	—	—	—	—	—
93	—	0.32	—	—	—	—	—
94	—	0.32	—	—	—	—	—
Number.	305	315	275	219	150	140	124
Average.	83.33	81.91	81.05	82.45	81.82	82.45	81.05
Maximum.	92.51	94.76	88.24	90.18	91.32	91.88	87.53
Minimum.	73.63	70.52	73.74	75.42	76.14	65.66	74.69

In Table XXVII (on page 228) is given the cephalic index of the Jews according to their nativity. The differences in the averages are very slight: the Galician Jews have an average cephalic index of 83.33, while the Lithuanian and Amerian Jews have only 81.05, the other groups, about 82. When compared with the Jews in Eastern Europe, we find that the headform is about the same as in the immigrants, with one slight exception to be noted when they are compared in groups representing the various types of headform. This has been done in Table XXVIII for the Polish, Lithuanian and Little-Russian Jews. For the rest there is no literature available, the present being the first measurements reported of Roumanian and Hungarian Jews.

TABLE XXVIII.[1]

CEPHALIC INDEX IMMIGRANT AND EASTERN EUROPEAN JEWS.

Type of Head.	Poland.		Lithuania.		Little-Russia.	
	N. Y.	Poland.	N. Y.	Lithuania.	N. Y.	Little-Russia.
-75	3.81	1.5	5.09	2.55	3.19	1.30
76-77	8.27	5.5	12.36	8.00	5.02	3.72
78-79	13.97	17.5	21.82	14.55	16.44	10.04
80-81	22.56	26.5	27.27	28.00	24.66	18.77
82-83	26.67	29.5	17.45	26.55	29.23	22.86
84-85	17.77	15.0	11.27	11.63	13.71	24.16
86 +	6.67	4.5	4.74	8.72	7.75	19.15

A comparison of the immigrant Jews from Galicia, with those in their native country (from Majer and Kopernicki's measurements) is here given:

Cephalic Index.	New York.	Galicia.
-74	0.64	3.63
75-77	5.89	3.87
78-80	23.28	13.80
81-84	48.87	49.40
85 +	21.32	29.30

From these tables we see that the proportion of dolichocephalic individuals, with a cephalic index less than 78 is larger in the

[1] The figures for the Eastern European Jews have been taken from the works of the following authors: Elkind, for the Polish Jews; Stieda, Talko-Hryncewicz, and Yakowenko, for the Lithuanian and White-Russian Jews; Weissenberg and Talko-Hryncewicz for the Little- and South Russian Jews.

immigrant Jews than among those in their native countries, while the proportion of brachycephalic individuals (cephalic index 84 and more) is larger among the stay-at-homes, than among the immigrants. There are only two exceptions — Galician Jews have 7.5 percent of dolichocephalic in Galicia, while those who emigrated to the United States have only 6.53 percent of persons with this type of head: and the Polish Jews have 24.44 percent of brachycephalic among the immigrants, as against 19.5 percent among those left at home. All the rest follow the rule that immigrants have a larger percentage of the dolichocephalic than brachycephalic type of headform. In the Galician Jews this possibly goes hand-in-hand with the absence of social selection which has been evident when stature was considered.

A comparison of the headform of the Jews with the indigeous populations of the countries in which they have lived is

TABLE XXIX.

CEPHALIC INDEX OF JEWS AND NON-JEWISH EASTERN EUROPEAN RACES.

Country.	Number Observed.	Average Cephalic Index.	75 and Less.	76 and 77.	78 and 79.	80 and 81	82 and 83.	84 and 85.	86 and more.	Observer.
Poland.										
Jews.	515	81.75	2.19	7.19	15.35	24.27	27.75	16.70	5.83	Elkind, Fishberg.
Poles.	226	80.85	2.65	17.25	22.57	20.36	23.45	7.97	5.75	Elkind.
Lithuania, and *White-Russia.*										
Jews.	550	81.10	3.82	10.18	18.18	27.64	22.0	11.45	6.74	Yakowenko, Stieda, Tal.
Letts.	476	80.60	2.52	6.30	13.86	21.85	23.95	19.76	11.76	Talko-Hryncewicz.
White-Russ.	961	83.20	2.81	5.83	13.22	20.09	22.58	18.52	16.96	Talko-Hryncewicz.
Little-Russia.										
Jews.	757	82.45	1.85	4.09	11.89	20.49	24.70	21.12	15.86	Talko, Weissenberg.
Little-Russ.	1055	83.20	1.23	2.56	7.96	17.54	23.52	21.61	25.59	Talko-Hryncewicz.
Roumania.										
Jews.	150	81.82	1.33	9.33	20.67	24.67	19.33	18.0	6.67	Fishberg.
Roumanians.	190	82.92	3.7	6.3	13.7	17.89	19.47	17.89	21.05	Pittard.

given in Table XXIX which shows some noteworthy characteristics.[1]

CEPHALIC INDEX OF JEWS, POLES AND RUTHENIANS IN GALICIA.

Type of headform.	Jews.	Poles.	Ruthenians.
–74	2.37	1.49	3.33
75–77	4.73	3.62	4.82
78–80	17.82	11.41	15.86
81–84	49.17	34.60	37.25
85 +	25.91	48.88	38.74

From these tables is seen that the headform of the Jews, when compared with the indigenous races of the countries from which they come, shows great similarities. In Galicia, where the cephalic index of the Ruthenians is 83.5, and that of the Poles is 84.4, that of the Jews is 83.33; in Russian-Poland, where the cephalic index of the Poles is only 80.85 (Elkind) the Jews also are more longheaded, having an average cephalic index of 81.75; the same is the case in Lithuania and White-Russia, where the Letts, are longheaded, with a cephalic index of 80.5 (Waeber), and even 78.5 according to Talko-Hryncewicz's measurements, as are also the Lithuanians, averaging 78.75 (Talko-Hryncewicz, Brennsohn). Here the Jews have an average cephalic index of 81.10.[2] South Russia, where the Little-Russians are predominating in numbers, is another center of brachycephaly, their cephalic index is over 83 on the average, and even 85.61 according to Belodied.[3] The Jews in this region of Russia have an average index of 82.45. In Roumania very few measurements have been taken on the indigenous population. From Pittard's recent work the Roumanians are seen

[1] The measurements of the non-Jewish races in this table are taken from the following works: For the Poles, Elkind, "The Wisla Poles," *Mem. Royal Soc. of Friends of Natural Science, Anthrop. and Ethnography*, Vol. 90, Moscow, 1896; Lithuanians and White-Russians, Talko-Hryncewicz, "Charakterystyka fizyczna ludowLitwy i Rusi," *Zbior Wiadom. do antropol. krajowej*, Vol. XVII, Krakow, 1893; Little-Russians, *idem.*, "Charakterystyka fizyczna ludu ukrainskiego," *ibid.*, Vol. XIV, Krakow, 1890; Roumanians, Pittard, *loc. cit.*, Galicia, Majer and Kopernicki, *loc. cit.*

[2] The White-Russians here are more broadheaded, 83.2 (Talko-Hryncewicz).

[3] Quoted from Ivanowski, *loc. cit.*

to have a cephalic index of 82.92.[1] The immigrant Jews from that country had a cephalic of 82.82, nearly the same as that found by Pittard in the indigenous population, the difference in one unit may possibly be accounted for by the fact that the measurements on Jews were taken on immigrants who, as we have seen are, as a rule, slightly more dolichocephalic. For the Jewish and non-Jewish population in Hungary the data are scanty. Steinberg found 54 *Szeklers* in Transylvania to be mesocephalic (cephalic index 81.4), while 69 Magyars were hyperbrachycephalic (cephalic index 87.8)[2] and Janko's measurements of 84 *Szeklers* gave an average index of 84.5. It will be seen that with such scanty and contradicting materials it is impossible to draw any conclusions. The Jews from that country had an average cephalic index of 82.45.

Considering that the cephalic index of the races in eastern Europe is almost uniformly confined within the limits of four units, 80 to 84, within the limits of personal error of observation and calculation of the observer, it must be agreed that the headform of the Jews agrees closely with that of the non-Jewish races and peoples in that region of Europe. This is confirmed by a close study of the figures presented in Table XXIX, showing the distribution of the classes of headforms in Jews and non-Jews in various eastern European countries where materials suitable for comparison are available. Thus longheaded individuals, with a cephalic index less than 78, are found among the Jews in the following order: 5.98 percent in Little-Russia, 7.1 percent in Galicia, 9.38 percent in Poland, 10.66 in Roumania, and 14 percent in Lithuania and White-Russia. Among the indigenous races in these countries the order is as follows: 3.79 percent among the Little-Russians, 5.11 among the Poles in Galicia (8.15 among the Ruthenians in that country), 8.80 among the Letto-Lithuanians and White-Russians, 10 percent among the Roumanians, and 19.9 among the Russian-Poles.

[1] Bassanovitch finds an average index of 77.5 in 106 Roumanian immigrants in Bulgaria; Himmel, 86.3 in 200 Roumanian soldiers in Bukowina, and Weisbach found them to be hyperbrachycephalic, 26 individuals in Transylvania averaged 87.2.

[2] Quoted from Weisbach, Körpermessungen, etc., pp. 201 and 227.

It is thus seen that with only one exception, the Russian-Poles, the order is the same among the Jews and non-Jews. Brachycephaly, cephalic index 84 and more, is among the Jews in the following order: Lithuania and White-Russia, 18.19 percent; Poland, 22.53; Roumania, 24.67; Galician, 25.91, and Little-Russian, 36.98. Among the non-Jews in these countries the order is as follows: Russian-Poles, 13.72 percent; Letto-Lithuanians, 21.52; White-Russians, 25.48; Roumania, 38.94; Galician-Ruthenians, 38.74, and Poles, 48.88, and finally Little-Russians, 47.1 percent. Here again we find that with the exception of the Polish Jews, the proportion of brachycephaly among the Jews depends on the proportion of persons with such heads among the Gentiles among whom they live.

Cephalic Index of the Women.

The average cephalic index of the 435 women was 83.24 — a little wider than that of the men. The maximum was 91.17 and the minimum, 71.47 — a difference of 20 units, or 24.09 percent of the average; thus showing a smaller range of extreme individual variation. The maximum diverged from the average by 8 units, 9.63 percent; and the minimum 12 units, 14.45 percent. showing the same tendency of more pronounced variability toward dolichocephaly, which was noted in men. The standard deviation was 3.419, and the probable error 0.110618, about the same as in men.[1] Classifying the date in classes as was done in the case of the men, we find the following distribution:

	Number.	Percent.
Hyperdolichocelphalic	5	1.15
Dolichocephalic	21	4.83
Subdolichocephalic	45	10.34
Mesocephalic	110	25.20
Subbrachycephalic	103	23.68
Brachycephalic	82	18.86
Hyperbrachycephalic	69	15.86
Total	435	100.00

[1] The larger value of the probable error being due to the fact that the number of women was smaller.

These figures show that the women display a greater tendency to brachycephaly, as is also seen by their average cephalic index. 5.98 percent of the Jewesses had a cephalic index of less than 78, while in Jews it reached 10.25 percent; brachycephalic heads, with an index of 84 and above, on the other hand, are found in the women 34.72 percent as against only 24.45 percent in the men. The proportion of mesocephalic heads is about the same in both sexes.

The seriation in Table XXX and the curve plotted on diagram 6 show the maximum frequency of occurrence (14.48 percent of all the women measured), to be at the cephalic index of 81. Women with an index of 82 were only found 10.57 percent, while the indices of 83 and 84 are again well represented, 13.1 and 12.18 percent respectively. A double apex is thus produced in the curve, one culminates at the index of 81

Table XXX.

Cephalic Index in 435 Jewesses.

Cephalic Index.	Number.	Percent.	Cephalic Index.	Number.	Percent.
71	1	0.23	82	46	10.57
72	1	0.23	83	57	13.10
73	—	—	84	53	12.18
74	—	—	85	29	6.67
75	3	0.69	86	28	6.44
76	12	2.75	87	15	3.45
77	9	2.07	88	8	1.84
78	26	5.98	89	10	2.29
79	19	4.37	90	6	1.38
80	47	10.80	91	2	0.46
81	63	14.48	Total.	435	99.99

and the other at 83–84, with a depression at the index of 82. This double apex is of significance, showing a greater variability of the headform of the women as compared with that of men. This phenomenon was already observed in our preliminary communication, where a lesser number of observations was reported. It is also to be noted in the anthropological literature of the Jews where measurements of heads of women are recorded. From Elkind's measurements of Polish Jewesses it is to be seen

that the curve for the cephalic index has two apices, one at the index of 82, and the other at 84.[1] Yakowenko's measurements of Jewesses in White-Russia also show a double apex in the curve for the cephalic index, one culminating at 77 and the other at 81.[2] In Talko-Hryncewicz's series of 206 Jewesses in Little-Russia there are even seen three apices in the curve for the cephalic index, at 80, 82 and 85.[3] The irregularity in the curves of the headform of the Jewesses is very remarkable from a biological standpoint. Throughout the animal kingdom the males are always known to show wider limits of variation in mental and physical character than do the females. Darwin[4] has brought together many examples to this effect, both in man and the lower animals; and Havelock Ellis[5] also shows that there is a greater tendency in man to diverge from the type than in woman. With the Jews, however, the reverse is the rule, so far as the headform is concerned, seems to apply, since it is the women who show the greater variability and differentiation.

In order to test this point we collected the measurements reported in the works of the following authors, and constructed a curve. From Weissenberg[6] 50 Jewesses in southern Russia; 125 Polish Jewesses from Elkind's work[7]; 206 Jewesses in Little Russia by Talko-Hryncewicz[8]; 100 women from Yakowenko's work,[9] all these were added to the 435 Jewesses here recorded, and thus a total of 916 women was obtained, a number which may be relied upon to give definite results. In Table XXXI and diagram 9 are given the seriation and the curve

[1] A. D. Elkind, "The Jews," *Memoirs of the Soc. of Friends of Natural Science-Anthropol. and Ethnography*, Moscow, 1902, p. 132 (in Russian).

[2] M. G. Yakowenko, "Materials for the Anthropology of the Jews," St. Peters, burg, 1898, p. 185 (in Russian).

[3] J. Talko-Hryncewicz, "Charakterystyka fizyczna ludnosci zydowskiej,' *Zbior wiadomosci do antropol. kraj., Krakow*, XVI, 1892, p. 45.

[4] "Descent of Man," Chap. VII: "Variation of Animals and Plants under Domestication," Vol. II, chap. XIV.

[5] "Man and Woman," London, 1893, chap. XVI.

[6] "Die südrussischen Juden," *Archiv f. Anthropol.*, XXIII.

[7] *Loc. cit.*

[8] *Loc. cit.*

[9] *Loc. cit.*

Table XXXI.

Cephalic Index of 916 Jewesses.

Cephalic Index.	Number.	Percent.	Cephalic Index.	Number.	Percent.
68	1	0.11	83	104	11.36
71	3	0.33	84	115	12.56
72	4	0.44	85	68	7.42
73	—	—	86	53	5.79
74	2	0.22	87	29	3.16
75	8	0.87	88	20	2.18
76	21	2.29	89	17	1.85
77	27	2.95	90	14	1.53
78	51	5.57	91	5	0.54
79	52	5.67	92	—	—
80	109	11.90	93	1	0.11
81	107	11.68			
82	105	11.46	Total.	916	100.00

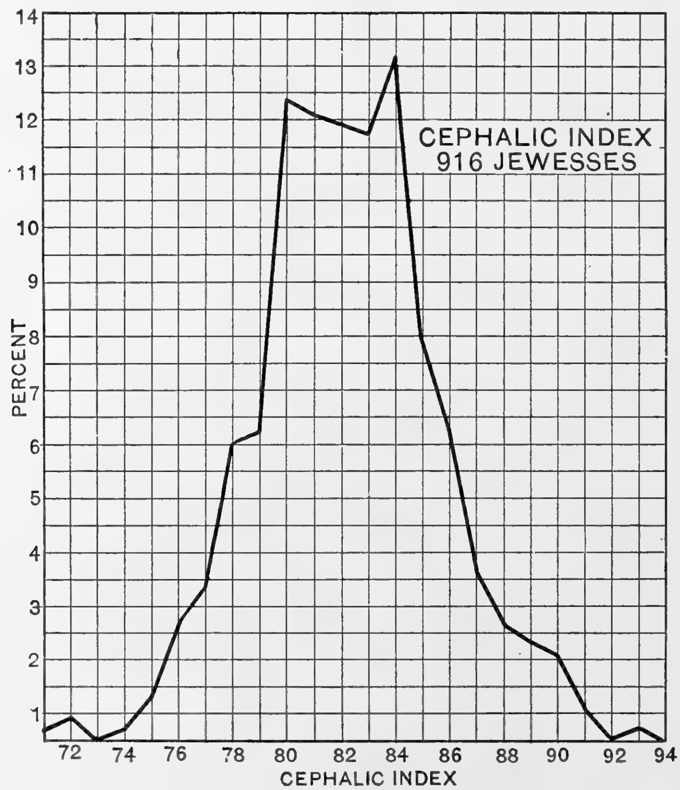

Fig. 9.

of these figures, which again show that the variability of the Jewesses as regards their head-form is much greater than that of the Jews. Here we have some evidence of two apices, one

at the index of 80 and the other at 84, both of which are connected by a more or less straight line: there is practically no depression between the two apices. In fact it may be considered that this curve has no culminating apex at all. Individuals with indices of 80 to 84 are encountered in about equal proportions, as can be seen from the flattening of the curve at its top. Whether the disturbing element in this case is some particula-racial element, will not be discussed now. It must however be pointed out that the same phenomenon is to be observed in the curve of the cephalic index of the men, although only to a lesser degree. There the flattening of the top of the curve extends only over three units, from 80 to 82, while in the curve of the women it extends over five units, from 80 to 84. The variability of the head-form of the women is thus shown to be

Table XXXII.

Cephalic Index of 435 Jewesses According to Nativity.

Cephalic Index.	Galicia.	Poland.	Lithuania and White-Russia.	Little-Russia.	Roumania.	Hungary.
71	0.82	—	—	—	—	—
72	—	—	1.00	—	—	—
73	—	—	—	—	—	—
74	—	—	—	—	—	—
75	—	—	1.00	1.35	2.27	—
76	0.82	8.93	4.00	2.70	—	—
77	1.64	1.79	4.00	2.70	—	—
78	5.74	3.57	3.00	10.81	2.27	12.82
79	4.92	5.36	3.00	2.70	6.82	5.13
80	5.74	19.64	13.00	13.51	9.09	5.13
81	9.99	19.64	12.00	22.97	18.18	7.69
82	8.20	12.50	12.00	14.86	9.09	5.13
83	14.75	5.36	20.00	8.11	6.82	17.95
84	11.47	8.93	10.00	6.76	25.00	20.51
85	10.66	5.36	3.00	5.41	9.09	5.13
86	9.99	1.79	7.00	4.05	6.82	5.13
87	5.74	1.79	5.00	1.35	2.27	—
88	4.09	—	1.00	—	—	5.13
89	2.46	1.79	1.00	1.35	—	10.26
90	2.46	1.79	—	1.35	2.27	—
91	0.82	1.79	—	—	—	—
No. observed.	122	56	100	74	44	39
Average.	84.83	81.77	83.24	82.22	83.24	83.15
Maximum.	91.81	91.87	88.41	88.73	90.19	89.92
Minimum.	71.58	76.40	72.38	74.39	75.84	78.72

greater than that of the men. It must be recalled in this connection, however, that the standard deviation, which many biologists consider the best measure of variability of physical characteristics is about the same in men (3.176), as in women (3.419). But even this tends to contradict the accepted opinion that the male is more apt to show wider limits of variation, and confirms Pearson's theory that when studied by modern mathematical methods, available data tend to show that any difference in the degree of variability in the sexes which may be discerned, women are slightly more variable than men.[1]

In Table XXXII are given the individual variations of the cephalic index of the Jewesses according to their nativity. Owing to the small number of observations in each group, it can not be expected that this should give reliable information as to the variability of the Jewesses in each of the named countries. Arranged in groups of types of headform, we may compare them with the Jewish women in Eastern Europe, wherever literature on the subject is available.

Table XXXIII.

Cephalic Index in Jewesses in the United States and in Eastern Europe.

Type of Headform.	Poland.		Lithuania and White-Russia.		Little-Russia.	
	New York.	Poland.	New York.	White-Russia.	New York.	Little-Russia.
-75	—	1.6	2.0	8.0	1.33	1.46
76-77	10.71	1.6	8.0	18.0	5.41	2.91
78-79	8.93	12.8	6.0	14.0	13.51	8.74
80-81	39.29	20.0	25.0	24.0	36.49	20.87
82-83	17.86	27.2	32.0	16.0	22.97	21.85
84-85	14.29	24.0	13.0	13.0	12.16	22.81
86+	8.93	12.8	14.0	7.0	8.11	21.36
No. observed.	56	120	100	100	74	206

There is no evidence of greater dolichocephaly in the immigrant Jewesses as was seen to be the case with the Jews. Thus in Galicia the average cephalic index of the Jewesses was found

[1] Karl Pearson, "The Chances of Death," chapter on "Variation in Men and Women."

to be 80.3 (Majer and Kopernicki), while the immigrant Jewesses from that country have an index of 84.83 on the average; in Poland the cephalic index of the Jewesses in Warsaw measured by Elkind was 82.92, while those from this country who emigrated to the United States, are seen to have an average index of 81.77; in White-Russia, the Jewesses observed by Yakowenko are more longheaded (81.24) than those who emigrated to the United States (83.23); and in Little-Russia, Weissenberg found the Jewesses with an average index of 82.4, and Talko-Hryncewicz 83.0, almost the same as that in the immigrant Jewesses from that region of Russia — 82.22. It is thus seen that with but one exception, the Polish Jewesses, the immigrant women are slightly more brachycephalic than those who remain at home. This is confirmed by the figures in Table XXXIII where it is seen that the proportion of dolichocephalic Jewesses is considerably larger in those who were measured in their native country than in the immigrants, excepting in those coming from Little-Russia. The proportion of brachycephalic among the immigrant Jewesses in each group bears no

TABLE XXXIV.

CEPHALIC INDEX IN JEWISH AND NON-JEWISH WOMEN IN EASTERN EUROPE.

Country.	Number Observed.	Average Cephalic Index.	75 and less.	76 and 77.	78 and 79.	80 and 81.	82 and 83.	84 and 85	86 and more.	Observer.
Poland.										
Jewesses.	181	83.18	1.10	4.22	11.60	25.97	24.31	21.00	11.60	Fishberg, Elkind.
Poles.	153	81.35	4.03	10.07	21.48	28.19	16.78	12.75	6.70	Elkind.
Lithuania.										
Jewesses.	200	82.00	5.00	13.00	10.00	24.5	24.00	13.00	10.50	Fishberg, Yakowenko
Letto-Lith.	107	80.60	4.67	14.95	11.21	26.17	17.76	11.21	14.03	Talko-Hryncewicz.
White-Russ.	141	82.30	7.09	0.71	9.93	25.53	23.40	21.28	12.06	Talko-Hryncewicz.
Little-Russia.										
Jewesses.	280	82.72	1.43	3.57	10.00	25.00	22.14	20.00	17.86	Fishberg, Talko-Hryncewicz.
Little-Russ.	237	83.40	—	2.53	8.02	14.34	30.80	19.41	24.90	Talko-Hryncewicz.

relation to the proportion found among the Jewesses measured at home and no definite conclusions can be drawn in this respect as to any form of social selection being at work.

When compared with the non-Jewish women of the countries in which these Jewesses have lived, it is found also that they do not follow the rule observed in men. They are not more dolichocephalic in countries where the indigenous women are so, nor are they more dolichocephalic in other places, as can be seen from Table XXXIV. The averages are the same as those in the non-Jewish women, but the distribution of the various classes of headform does not correspond to that of the Gentiles. Possibly this is due to the limited number of observations on Jewesses, or there is some other reason, which is not apparent to the present writer.

The Horizontal Circumference of the Head.

The average horizontal circumference of the head of 1,528 Jews was 55.55 cm. (twenty-two inches). The range of extreme individual variation was rather small. With a maximum of 64.3 cm., and a minimum of 48.2 cm., the variation extended over only 16.1 cm., or 29 percent of the average. This is much smaller than that which has been found for the stature of the Jews, the length and width of the head, etc. The accompanying table gives in detail the number and percentage of individuals with a given size of the head, at intervals of five millimeters. It will be observed that while the maximum number of individuals (12.82 percent) had heads corresponding to the average, 55.55 cm., still the frequency of occurrence on both sides of the median does not progressively get smaller. A curve drawn from these figures does not run as smooth a course as we have observed to be the case with other measurements of the head of the Jews. This can be explained, first, because the chances of error in observation are very great while taking measurements of the horizontal circumference of the head with the tape, much greater than when straight lines are measured with the calipers. This condition has influenced the present writer to such an extent that he has discarded the measurements of the horizontal cir-

TABLE XXXV.

HORIZONTAL CIRCUMFERENCE OF THE HEAD.

mm.	Number.	Percent.	mm	Number	Percent.
481–485	1	0.07	566–570	173	11.32
486–490	—	—	571–575	101	6.61
491–495	1	0.07	576–580	67	4.38
496–500	—	—	581–585	49	3.21
501–505	5	0.33	586–590	29	1.89
506–510	2	0.13	591–595	15	0.99
511–515	13	0.85	596–600	9	0.60
516–520	13	0.85	601–605	4	0.26
521–525	34	2.21	606–610	1	0.07
526–530	35	2.28	611–615	1	0.07
531–535	66	4.32	616–620	—	—
536–540	95	6.21	621–625	1	0.07
541–545	162	10.60	626–630	1	0.07
546–550	149	9.75	631–635	1	0.07
551–555	165	10.80	636–640	1	0.07
556–560	196	12.83			
561–565	138	9.02	Total.	1,528	100.00

cumference of the head in women as worthless, because owing to the hair and the head dressings, the difficulties are quite serious.

The circumference of the head was 33.77 percent of the average stature ($100 \times \frac{55.55}{164.5} = 33.77$). The tall men who were 170 cm. and taller in height, had relatively smaller heads than those who were short of stature, less than 160 cm. and less. This is best seen in the accompanying table :

Stature.	Average Stature.	Average Circumference of the Head.	Percent of Stature.
Tall (less than 160)	173.4	56.05	32.32
Above the average	167.1	55.79	33.38
Below the average	162.6	55.62	34.21
Short	156.1	54.79	35.10

which shows that while with the increase of stature the horizontal circumference of the head also increases, but when considered in relation to stature, the size of the head decreases. The men of short stature had a circumference of the head of 35.1 percent of their body height, while the tall people's heads averaged only 32.32 percent of their stature. This is best seen in the accompanying table :

Stature.	Calculated Circumference of the Head.	Observed Circumference of the Head.	Difference (in mm.).
Tall	58.56	56.05	—2.51
Above the average	56.43	55.79	—0.64
Below the average	54.91	55.62	+0.71
Short	52.71	54.79	+2.08

We see from these figures that the short men measured around their heads 2.08 cm. more than would be expected if their heads were proportionately as large as the average of all the Jews measured, is to the average stature. On the other hand, the tall men had heads 2.51 cm. shorter theoretically expected.

There is practically no difference in the absolute and relative circumference of the head in the Jews from various countries in eastern Europe, as is to be seen from the following figures:

Nativity.	Average Circumference of the Head.	Percent of Stature.
Galicia	55.10	33.35
Poland	55.42	33.92
Lithuania	55.61	33.87
Little-Russia	55.62	33.56
Roumania	55.81	33.62
Hungary	55.77	33.66
United States	56.18	33.46

Measurements taken on Jews in Eastern Europe agree closely with our results, the circumference of the head is about 55 to 56 cm. on the average. It should be noted also that the same is about the average of the non-Jewish races in this region of Europe.

CHAPTER V.

The Face.

The height of the face was measured with calipers, by taking the distance from the root of the nose to the point beneath the middle of the chin. The average height was 119 mm. in Jews, and 109 in Jewesses. The maximum height was 142 mm. in men and 128 in the women; the minimum 98 mm. in men, and 90 in the women. The amplitude of extreme individual variation

Table XXXVI.

Height of the Face of Jews and Jewesses.

Height of the Face (in mm.).	Jews.		Jewesses.	
	Number.	Percent.	Number.	Percent.
89– 90	—	—	1	0.23
91– 92	—	—	—	—
93– 94	—	—	1	0.23
95– 96	—	—	11	2.52
97– 98	1	0.07	12	2.76
99–100	4	0.26	17	3.91
101–102	5	0.33	20	4.59
103–104	12	0.78	25	5.77
105–106	20	1.31	49	11.26
107–108	27	1.77	34	7.82
109–110	82	5.37	69	15.86
111–112	85	5.56	48	11.04
113–114	99	6.48	37	8.51
115–116	153	10.01	47	10.80
117–118	170	11.12	25	5.76
119–120	234	15.32	26	5.95
121–122	149	9.75	5	1.15
123–124	122	7.98	5	1.15
125–126	126	8.24	1	0.23
127–128	70	4.58	2	0.46
129–130	106	6.94	—	—
131–132	36	2.36	—	—
133–134	12	0.79	—	—
135–136	8	0.52	—	—
137–138	4	0.26	—	—
139–140	2	0.13	—	—
141–142	1	0.07	—	—
Total.	1,528	100.00	435	99.98

is very large, amounting to 44 mm. or 37.9 percent of the average in the men. and 38 mm. or 34.86 percent of the average in the women. The great variability of this measurement is also seen from the large value of the standard deviation, which was 6.56 in the men, and 6.52 in the women. It is thus much larger than the standard deviation of any other measurement obtained

Table XXXVII.

Width of the Face of Jews and Jewesses.

Width of the Face (in mm.).	Jews.		Jewesses.	
	Number.	Percent.	Number.	Percent.
105–106	—	—	1	0.23
107–108	—	—	1	0.23
109–110	—	—	—	—
111–112	—	—	5	1.15
113–114	1	0.07	3	0.69
115–116	1	0.07	11	2.53
117–118	8	0.52	9	2.07
119–120	13	0.84	28	6.42
121–122	29	1.89	35	8.05
123–124	26	1.70	37	8.51
125–126	54	3.54	53	12.18
127–128	65	4.25	59	13.57
129–130	175	11.45	77	17.70
131–132	186	12.18	44	10.12
133–134	130	8.51	29	6.66
135–136	206	13.48	22	5.05
137–138	174	11.39	13	2.99
139–140	156	10.21	5	1.15
141–142	127	8.31	2	0.46
143–144	79	5.17	1	0.23
145–146	55	3.60	—	—
147–148	28	1.83	—	—
149–150	8	0.52	—	—
151–152	3	0.21	—	—
153–154	2	0.13	—	—
155–156	2	0.13	—	—
Total.	1,528	100.00	435	99.99

on the Jews, excepting those of the nose. The probable error was 0.112 in men and 0.149 in the women. The seriation of the measurements, as seen in Table XXXVI shows a striking uniformity of type. The apex of the curve for the measurements in men corresponds to the median, and on both sides the values are quite evenly distributed the percentage of individuals with a given height of the face, is getting progressively smaller, the

farther it is from the median. There is however no such uniformity to be observed in the curve for the women ; here there are four apices observable, which would seem to indicate a greater variability of the height of the face of Jewesses.

The average width of the face was as follows :

	Average.	Maximum.	Minimum.
Jews	135	156	114
Jewesses	127	143	107

The range of extreme individual variation was in Jews, 31.11 percent and in Jewesses, 28.34 percent of the average width of the face, which would indicate a lesser variability than that observed in the height of the face of the Jews. The standard deviation is, however, large. In men it is found to amount to 6.25, and in the women, 5.87. The probable error also is large, in the men, 0.1072, and in the women, 0.1895, about the same as in the case of the height of the face. The distribution of the various values obtained by measurement, is given in the accompanying table XXXVII, showing that in the case of both men and women, there is a fair uniformity of type.

There is very little difference in the average width and height of the face of Jews from various countries, as can be seen from the following figures :

Nativity.	Average height.		Average width	
	Jews.	Jewesses.	Jews.	Jewesses.
Galicia	119	107	132	128
Poland	119	110	132	129
Lithuania and White-Russia	119	109	135	126
Little-Russia	120	110	137	125
Roumania	120	113	135	128
Hungary	119	110	136	127
United States	120		124	

The average height is in each group 119 or 120 mm. in the Jews and 107 to 113 mm. in the Jewesses. The slight difference in the Jewesses may be explained by the comparatively small number of observations. The width of the face is similarly almost the same in each group.

The Facial Index.

The average of the facial index was in men, 88.15, and in women 85.83. The variability was considerable, as can be seen from Table XXXVIII. It extended in the men over 38 units (maximum, 107, and minimum, 69) or 43 percent of the average; in women over 30 units (maximum 100, and minimum, 70) or 35 percent of the average. The standard deviation was 5.83 in men and 5.7 in the women. The probable error, in men 0.1, and in women 0.18.

Table XXXVIII.

Facial Index in Jews and Jewesses.

Facial Index.	Men.		Women.	
	Number.	Percent.	Number.	Percent.
69– 70	1	0.07	1	0.23
71– 72	3	0.21	1	0.23
73– 74	11	0.72	6	1.38
75– 76	16	1.05	16	3.68
77– 78	33	2.16	15	3.45
79– 80	75	4.90	35	8.05
81– 82	111	7.26	46	10.57
83– 84	162	10.60	43	9.89
85– 86	193	12.63	65	14.94
87– 88	222	14.53	61	14.02
89– 90	190	12.43	52	11.95
91– 92	172	11.26	34	7.82
93– 94	128	8.37	27	6.21
95– 96	92	6.02	20	4.59
97– 98	48	3.14	6	1.38
99–100	46	3.01	6	1.38
101–102	14	0.91	1	0.23
103–104	6	0.40	—	—
105–106	2	0.13	—	—
107–108	3	0.21	—	—

There is little difference in the facial index of Jews from various countries as can be seen from the following figures:

Nativity.	Facial index. Men.	Women.
Galicia	90.15	83.59
Poland	90.15	85.27
Lithuania and White-Russia	88.15	86.51
Little-Russia	87.59	88.00
Roumania	88.89	88.28
Hungary	87.50	86.62
United States	87.59	

CHAPTER VI.

The Nose.

The measurements, shape and form of the nose have been considered by anthropologists to be more or less fixed in the various races of mankind, and are consequently a valuable test of race. "Few physical characters yield more uniform results than does the nose . . . . A careful study of this organ shows almost better than any other the coördination of parts in the facial features generally."[1] Of the various measurements and characteristics suggested by Topinard as of value in the study of this organ,[2] I have only taken measurements of the height and width of the nose, calculated the nasal index in 1,510 Jews and in 423 Jewesses, and taken notes of the shape and form in 2,836 Jews and 3,284 Jewesses. Measurements of the upper width of the nose (the distance between the inner angles of the eyes), the projection, extreme length, etc., could not be obtained in sufficient number, because of the objections on the part of the majority of the individuals measured to excessive manipulation on my part around their nose.

Height of the Nose.

The average height of the nose, measured from the root to the subnasal spine, was found to be in 1,510 Jews, 52 mm., and in 423 Jewesses, 47 mm. The maximum in the Jews was 66 mm. and in the Jewesses 58 mm. The minimum height, in Jews, 40 mm., and in Jewesses, 39 mm. The range of extreme individual variation is thus seen to be very large, 50 percent of the average height in men and 40.42 percent in women. In the case of the stature of the Jews, which is a very fluctuating character, this was only 31.61 percent of the average value, and in the length and width of the head it was even smaller.

[1] A. H. Keane, "Ethnology," Cambridge, 1901, p. 185.

[2] P. Tepinard, "Elements d'anthropologie generale," pp. 301–307; also A. Bertillon, "Morphologie du Nez," *Rev. d'Anthropologie*, 3d series, Vol. II, 1887.

Table XXXIX.

Height of the Nose of Jews.

Height of the Nose.	Jews.		Jewesses.	
	Number.	Percent.	Number.	Percent.
39-40	1	0.06	5	1.18
41-42	8	0.52	25	5.91
43-44	30	1.99	58	13.71
45-46	65	4.31	70	16.55
47-48	135	8.94	88	20.80
49-50	270	17.88	91	21.52
51-52	305	20.19	62	14.66
53-54	299	19.81	19	4.49
55-56	198	13.12	4	0.95
57-58	92	6.10	1	0.23
59 60	69	4.57	—	—
61-62	24	1.59	—	—
63-64	10	0.66	—	—
65-66	3	0.19	—	—
71	1	0.06	—	—
Total.	1,510	99.99	423	100.00

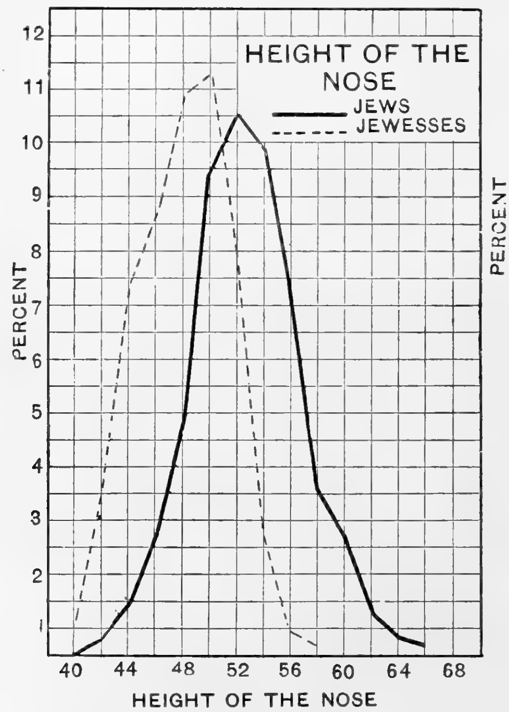

Fig. 10.

In Table XXXIX is given the seriation of the values obtained by measurement of the height of the nose at intervals of two

mm. It will be observed that the height of the nose in the largest proportion of individuals was equal that of the average and median value. This is evident in both the men and women, in the latter it appears that the height of 49 to 50 mm. was more frequent than the height of 47 to 48 mm., but the difference was very small, less than one percent.

The standard deviation is quite large — 4.008 in the Jews, and 3.368 in Jewesses. The probable error is in men 0.06947, and in women 0.1099. This indicates a greater variability of the women, but this is to be attributed to the fact that the number of Jewesses examined is about one-third that of Jews.

Width of the Nose.

The width of the nose was taken with a sliding compass, by measuring the distance of the alæ without compressing them. The average width of the nose is in Jews 36.35 mm., and 32.92 mm. in Jewesses. The maximum width was in men 48 mm. and in women 43 mm. The minimum width of the nose was 27 mm. in men and 25 mm. in women. The difference between the maximum and minimum width of the nose was 21 mm. or 43.75 percent of the average in the Jews, and 18 mm. or 54.54 percent of the average width in the Jewesses. The variability of the nose in women is thus shown to be greater than that of the men.

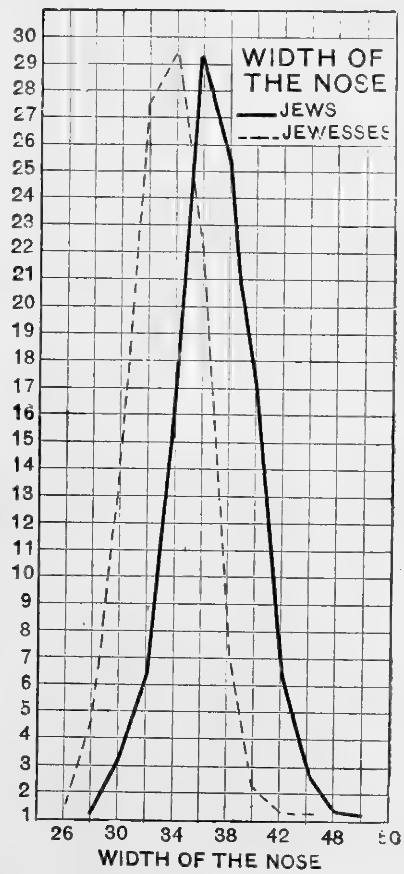

Fig. 11.

Table XL shows the seriation of the values obtained by measurement of the width of the nose in Jews and Jewesses. The average width corresponds to the median and is in the most frequently occurring group. A curve plotted from these figures will run a more or less smooth course.

Table XL.

Width of the Nose in Jews and Jewesses.

Width of the Nose.	Jews.		Jewesses.	
	Number.	Percent.	Number.	Percent.
25–26	—	—	1	0.23
27–28	3	0.19	16	3.78
29–30	33	2.19	53	12.53
31–32	82	5.44	112	26.48
33–34	234	15.50	121	28.61
35–36	428	28.34	86	20.33
37–38	368	24.37	27	6.39
39–40	244	16.16	5	1.18
41–42	83	5.50	1	0.23
43–44	26	1.72	1	0.23
45–46	6	0.40	—	—
47–48	3	0.19	—	—
Total.	1,510	100.00	423	99.99

The standard deviation is for the Jews, 2.968, and for the Jewesses 2.567, much smaller than that found in the case of the height of the nose. The probable error is in men 0.5328, and in women 0.8364.

There is almost no difference in the average height and width of the nose of the Eastern European Jews in the various countries, as can be seen from the following figures:

Country.	No. Observed.	Average.	
		Height.	Width.
Galicia.			
Men	295	52	36
Women	117	47	33
Poland.			
Men	307	51	37
Women	56	47	33
Lithuania and White-Russia.			
Men	275	52	36
Women	100	48	33
Little-Russia.			
Men	219	53	37
Women	67	48	33
Roumania.			
Men	150	52	36
Women	44	52	36
Hungary.			
Men	140	51	36
Women	39	47	32
United States.			
Men	124	53	36

The Nasal Index.

The nasal index, calculated by multiplying the width of the nose by 100 and dividing the product by the height of the nose, was in men 69.23 and in women 69.14—identical in both sexes. The distribution of the individual indices according to Collignon's classification, is as follows :

	Men.		Women.	
	Number.	Percent.	Number	Percent.
Leptorrhinian (index less than 70)....	760	50.53	210	49.65
Mesorrhinian (index 70 to 84.9).......	692	45.83	202	47.75
Platyrrhinian (index 85 to 100)	58	3.84	11	2.60
Total..................................	1,510	100.00	423	100.00

It is evident from these figures that both Jews and Jewesses are generally leptorrhinian. Broad noses are quite infrequent,

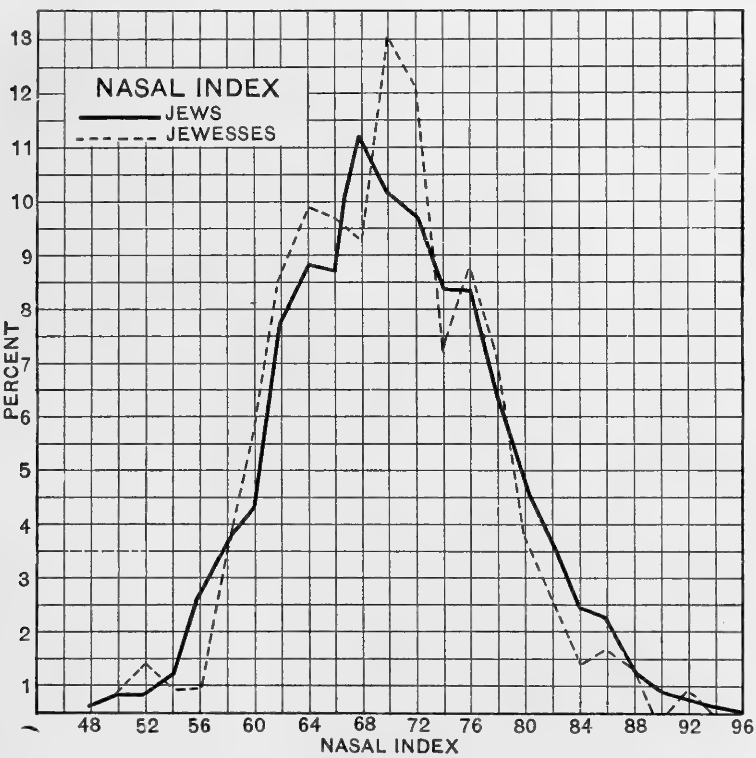

Fig. 12.

only 3.84 percent of men and 2.60 percent of women had nasal indices of over 85.

The maximum nasal index was in men 100 and in women 92; the minimum, in men 40 and in women 49. It is thus shown that the extreme individual variation extended: In the Jews — the maximum was 44.92 percent larger than the average, and the minimum was 42.03 percent smaller than the average nasal index; in the Jewesses these figures stand 33.33 and 29.00 percent respectively. The range of extreme individual variation,

Table XLI.

Nasal Index in Jews and Jewesses.

Basal Index.	Jews.		Jewesses.	
	Number.	Percent.	Number.	Percent.
40	1	0.06	—	—
47– 48	2	0.13	—	—
49– 50	6	0.40	2	0.47
51– 52	6	0.40	4	0.95
53– 54	18	1.19	2	0.47
55– 56	33	2.19	2	0.47
57– 58	48	3.18	12	2.84
59– 60	56	3.71	22	5.20
61– 62	109	7.22	34	8.04
63– 64	127	8.41	40	9.45
65– 66	125	8.28	39	9.21
67– 68	162	10.73	37	8.75
69– 70	145	9.60	53	12.53
71– 72	138	9.13	47	11.53
73– 74	119	7.88	28	6.62
75– 76	118	7.82	35	8.28
77– 78	91	6.00	28	6.62
79– 80	67	4.44	14	3.31
81– 82	51	3.38	9	2.13
83– 84	30	1.99	4	0.95
85– 86	26	1.72	5	1.18
87– 88	11	0.73	4	0.95
89– 90	7	0.46	—	—
91– 92	5	0.33	2	0.47
93– 94	4	0.28	—	—
95– 96	3	0.19	—	—
97– 98	—	—	—	—
99–100	2	0.13	—	—
Total.	1,510	99.98	423	100.00

as indicated by the difference between the maximum and minimum was 86.95 percent of the average nasal index of the Jews and 62.32 percent in the Jewesses. This can be considered a very large variability, larger in men than in women, and again confirming the fact that the nose is the most variable of the traits we have studied in the Jews.

The accompanying table (XLI) shows the distribution of the individual nasal indices at the interval of two units. It will be observed that individuals with a nasal index of 69 are the most common among the Jewesses; in the Jews, the most frequent nasal index is 67, and not 69, the average. A curve

TABLE XLII.

NASAL INDEX OF THE JEWS ACCORDING TO THEIR NATIVITY.

Nasal Index.	Galicia.	Poland.	Lithuania and White-Russia	Little-Russia.	Roumania	Hungary.	United States
40	0.34	—	—	—	—	—	—
47– 48	0.34	—	—	—	—	—	—
49– 50	1.02	0.32	0.36	—	0.67	0.71	—
51– 52	0.67	0.32	0.36	—	—	—	1.61
53– 54	1.70	1.96	—	0.45	2.67	—	1.61
55– 56	3.73	0.98	1.45	2.28	2.67	1.42	3.23
57– 58	3.05	0.98	4.73	2.74	4.00	2.86	5.65
59– 60	4.75	2.28	3.28	3.65	3.33	5.72	4.03
61– 62	9.15	4.56	10.18	8.67	4.00	5.72	5.65
63– 64	9.83	7.17	6.91	9.13	10.00	10.00	6.45
65– 66	6.10	7.82	6.18	9.13	9.33	9.29	15.32
67– 68	7.12	13.03	10.55	11.87	16.67	5.72	10.49
69– 70	9.50	11.73	7.64	11.42	10.00	7.86	7.26
71– 72	9.83	7.49	9.09	10.50	7.33	11.43	8.87
73– 74	6.44	7.82	8.73	9.13	8.67	4.30	10.49
75– 76	8.82	11.40	7.27	5.02	6.00	8.57	4.03
77– 78	4.41	6.84	5.46	4.57	4.00	11.43	8.07
79– 80	5.76	3.58	5.46	5.02	2.67	5.00	1.61
81– 82	2.37	4.23	5.82	2.74	2.00	3.57	0.80
83– 84	2.03	1.96	2.54	2.28	2.00	2.86	—
85– 86	1.70	2.93	1.45	0.45	1.33	0.71	2.42
87– 88	0.67	0.32	0.73	0.91	—	0.71	1.61
89– 90	0.34	0.32	0.73	—	2.00		—
91– 92	—	1.30	—	—	—	0.71	–
93– 94	—	0.32	0.36	—	0.67	1.42	—
95– 96	0.34	—	0.36	—	—	—	0.80
97– 98	—	—	—	—	—	—	—
99–100	—	0.32	0.36	—	—	—	—
Number.	295	307	275	219	150	140	124
Average.	69.23	72.55	69.23	69.81	69.23	70.59	67.92
Maximum.	95.34	100.00	100.00	88.74	93.18	93.74	95.42
Minimum.	40.14	50.18	50.79	54.23	50.94	48.27	51.83

drawn from these figures displays a striking variability of the nasal index. Although each ordinate is made up of two units, instead of one as was done with the cephalic index, it is to be noted that the curve is very irregular in its course, and its legs

in both sides diverge widely, they are not as close together as those in the curve for the cephalic index. All this again emphasizes the great variability of the nose in Jews.

This large variability of the form of the nose in Jews is again displayed when the standard deviation is calculated. It amounted to 8.07 in Jews and 7.117 in Jewesses, which is larger than that of any other trait thus far considered in our investigation. The probable error is correspondingly large: 0.1396 in Jews and 0.2333 in Jewesses. The difference in the nasal index of the Jews according to their nativity is almost insignificant. As can be seen from Table XLII giving the seriation of the nasal index in Jews and Jewesses according to their country of birth.

Table XLIII.

Nasal Index of Jewesses According to their Nativity.

Nasal Index.	Galicia.	Holand.	Lithuania and White-Russia	Little Russia.	Roumania.	Hungary.
49–50	0.85	—	—	—	2.27	—
51–52	1.71	—	—	—	4.55	—
53–54	—	—	—	2.99	—	—
55–56	—	1.79	—	—	—	2.56
57–58	1.71	—	4.00	4.48	4.55	2.56
59–60	2.57	1.79	9.00	5.97	4.55	7.69
61–62	6.00	3.57	9.00	8.96	18.18	5.13
63–64	6.00	10.71	12.00	13.43	9.09	5.13
65–66	9.40	12.50	5.00	7.46	11.36	15.38
67–68	8.55	8.93	9.00	8.96	2.27	15.38
69–70	14.53	17.86	14.00	5.97	6.82	12.82
71–72	12.82	10.71	10.00	13.43	9.09	7.69
73–74	11.11	5.36	1.00	5.97	9.09	7.69
75–76	10.25	5.36	9.00	7.46	4.55	10.26
77–78	5.13	12.50	8.00	4.48	6.82	2.56
79–80	1.71	3.57	5.00	5.97	—	2.56
81–82	3.42	1.79	1.00	2.99	2.27	—
83–84	1.71	—	2.00	—	—	—
85–86	0.85	1.79	1.00	—	4.55	—
87–88	0.85	1.79	—	—	—	2.56
89–90	—	—	—	—	—	—
91–92	0.85	—	—	1.49	—	—
Number.	117	56	100.00	67	44	39
Average.	70.21	70.21	68.75	68.75	69.23	68.09
Maximum.	91.49	87.36	88.12	92.42	86.23	88.18
Minimum.	49.09	50.58	57.34	54.13	50.33	55.14

The Shape of the Nose.

The "Jewish" nose has been considered characteristic. Caricaturists have exploited this part of the Jewish anatomy to an extent which, as we shall see hereafter, is not warranted by statistical facts. Whenever a Jewish face is pictured, a hooked nose, one which looks like the beak of a parrot is generally portrayed. Even anthropologists have been led astray by this popular notion. Topinard, in his classification of noses, calls the hooked nose, the Jewish or Semitic nose. He enumerates several varieties of convex noses, generally known as aquiline: The simple aquiline, the "arched," some of which have the appearance of the beak of the parrot, others of the eagle ("bec dé perroquet," "bec d'aiglé") according to the direction taken by the extreme point of the nose. But the investigations of anthropologists do not bear out the contention that the hook nose is characteristic of the Jews, at least as far as Jews from Eastern Europe are concerned.

The present author has taken notes on the shape of the nose in 4,120 Jews in New York City, which includes Jews from all parts of Europe as well as natives. The results are shown in the following table.

Variety of Noses in 4,120 Jews and Jewesses.

Variety of Nose.	Jews.		Jewesses.	
	Number.	Percent.	Number.	Percent.
Straight	1,624	57.26	763	59.42
Hooked, aquiline	404	14.25	163	12.70
Retroussé (snub)	626	22.07	178	13.86
Flat and broad	182	6.42	180	14.02
Total	2,836	100.00	1,284	100.00

This shows that the predominant variety of nose-form among the Jews in New York City is the straight — 57 percent of Jews and 59 percent of Jewesses had straight noses. This variety of nose is known as the "Greek" nose, because the ancient Greek sculptors have usually produced in their statues faces with straight noses. But noses modeled after the form of the Greek monuments are very rare among all races. This is true partic-

ularly of that part where the root of the nose joins the forehead, which is represented in the productions of the masters as almost straight with almost no depression at all. The straight noses observed in the modern population of Europe show a more or less deep indentation at the root, while the dorsum is more or less straight.

The "retroussé," concave or "snub" (known popularly as the saucy nose) noses were observed in 22 percent of the Jews and in 13 percent of the Jewesses. This variety of nose is usually short and comparatively broad; when looked at in profile the dorsum is seen to be short and but little elevated, while the nostrils are often directed upwards on both sides. The root is generally broad, low, and the dorsum is concave. This concavity may be of various degrees. It appears that Galician Jewesses very frequently have this form of nose. This variety of nose is very frequent in the Slavic races, particularly in the Ukraine among the Little-Russians, and in Galicia among the Ruthenian peasantry. It is a striking fact that these noses are also most often encountered among the Jews coming from these localities.

The proportions of hooked noses among the Jews in New York was found to be 14 percent in the men and 12 percent in the women, which contradict flatly the prevailing popular opinion that every Jew is the possessor of a hook nose. This fact is also confirmed by statistics given in the works of other investigators. Thus, Majer and Kopernicki found among the Galician Jews 30.9 percent of hook noses; Blechman in Russia only 2 percent; Weissenberg in South Russia only 14 percent; in Poland Elkind reports only 10 percent in Jews and 4 percent in Jewesses; Yakowenko in White-Russia found only 9.79 percent, and Talko-Hryncewicz found among the Jews of the Ukraine 26.3 percent of hook noses in the men, and among the women only 18.9 percent; while among the Lithuanian Jews the proportion was only 21.7 percent. We thus see that the proportion of hook noses among the Jews fluctuates between 2 and 30 percent, by far not as universal as caricaturists would lead one to believe. It is remarkable that hook noses are not

infrequent in the non-Jewish population of Eastern Europe. Among the Poles in Galicia 6.4 percent have this variety of nose, and the Ruthenians of the same country also have 6 percent of hook-nosed individuals (Majer and Kopernicki). Among the Little-Russians Talko-Hryncewicz found over 10 percent among both men and women. The hook nose is thus not much more often encountered among the Eastern European Jews than among the Gentile populations of this region. On the other hand, in Asia Minor and in the Caucasus the arched or "Jewish" nose is very often seen among the indigenous races, such as the Armenians, Syrians, Georgians, Ossetts, Lesghians, Aisores, etc.; in fact, this form of nose is among these races more frequent than among the Eastern European Jews.

There are various explanations why popular opinion artists and even scientists have always considered the arched nose peculiarly Jewish. Beddoe believes that it is due to a characteristic tucking up of the wings. Joseph Jacobs concludes that "the nose does contribute much toward producing the Jewish expression, but it is not so much the shape of its profile as the accentuation and flexibility of the nostrils." From his composite photographs of Jewish faces he shows that when the nose is covered the Jewish expression disappears entirely, and that it is the so-called "nostrility" which makes these composites "Jewish." "A curious experiment illustrates this importance of the

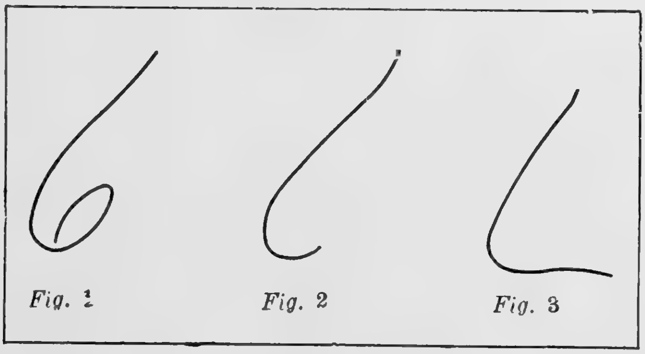

FIG. 13.

nostril toward making the Jewish expression. Artists tell us that the very best way to make a caricature of the Jewish nose

is to write a figure 6 with a long tail (Fig. 1); now remove the turn of the twist as in fig. 2, and much of the Jewishness disappears; and it vanishes entirely when we draw the continuation horizontally as in fig. 3. We may conclude then that, as regards the Jewish nose, that it is more the Jewish nostril than the nose itself which goes to form the characteristic Jewish expression."[1] Ripley agrees with Jacobs on this point, and concludes that next to dark hair and eyes and a swarthy skin, the nostrils are the most distinctive feature among the Jews.[2] It is to be regretted that during this investigation of the somatology of the Jews, the present writer has taken no statistics of the frequency of this so-called nostrility, and is not in a position to either confirm or deny the contention. As it is, it seems that the "nostrility" is mostly found among those Jews who have arched noses, and is only rarely observed in those with straight or snub noses, and that among the inhabitants of Asia Minor and the Caucasus, who as was already mentioned, have arched noses, this nostrility is also very frequent.

[1] J. Jacobs, "On the Racial Characteristics of Modern Jews," *Journ. Anthropol. Institute,* 1886, XV, pp. 23-62.

[2] Wm. Z. Ripley, "The Races of Europe," p. 395.

CHAPTER VII.

Pigmentation.

Judging from Biblical data, it appears that the color of the hair of the ancient Hebrews was black, "raven black" appears to have been the ideal of beauty, as is seen from Cant. IV, 1; V, 11. Black hair is designated as a sign of youth in contrast with the white hair of old age. Josephus narrates that Herod dyed his gray hair black in order to appear younger.[1] Black hair was considered beautiful, says Benzinger, black being the general color, while light or blond hair was exceptional.[2] King David and also Esau are credited with having red or "ruddy" hair.[3] The color of the eye is not indicated in the Bible or Talmud, although this organ is mentioned more than 800 times in the Bible, and is described in detail as regards other characteristics such as the anatomy, expression, etc. It may be mentioned in this connection though that according to some Hebrew scholars there is no equivalent in the Hebrew language for "blue" in either Bible or Talmud.

If black was the color of the hair of the ancient Hebrews, then it is evident that the modern Jews have not preserved the type. Our investigations of this trait has included 4,235 individuals over twenty years of age; of these 2,716 were men and 1,519 women. Besides the color of the hair and eyes observations have been made on grayness, baldness and freckles, and also on the variety of the hair.

As will be readily observed by one who attempts to distinguish the degrees of pigmentation of the skin, hair and eyes, there is often considerable difficulty in deciding which color to assign a given individual. It is quite easy to distinguish golden blond from black or dark brown hair. But between these two

[1] "Ant.," XVI, 8, I, quoted from Jewish Encyclopedia, Vol. VI, p. 157.

[2] Art, "Hair," Jewish Encyclop., VI, p. 157.

[3] I Samuel, XVI, 12; XVII, 42; Genesis XXV, 25.

extremes there are found minor gradations which are not easily separated, and one often remains in doubt as to the class with which he is dealing. There also arises a problem concerning the number of colors into which it is advisable to divide the material. Some anthropologists distinguish as many as fifteen colors of skin, hair or eyes; while the late Dr. Virchow, in his classical elaboration of the material on the color of skin, hair and eyes of German school children, collected by the German anthropological Society[1] distinguishes only two colors for the skin (fair and dark), four for the hair (blond, brown, black, and red), and three for the eyes (blue, gray, and brown). This classification we have adopted, with only slight modifications; we distinguish six classes of hair coloration—black, brown, chestnut, light chestnut, blond, and red.

The distinction between fair and dark skin is not always readily apparent, and in doubtful cases we have been guided by the general impression gained by a careful inspection at a distance from one to two meters from the individual. Only those whose skin appeared brownish or swarthy were taken as dark, and those having a yellowish or somewhat muddy tint were regarded as fair.

The hair was considered black when the darkness was very deep, without a brownish tinge. Such hair usually has a luster which by reflected light gives it a bluish appearance, but this luster is not observable in black hair which is not kept scrupulously clean by frequent brushing.

Brown hair was considered to be that which, although fairly dark, did not show a luster, or in reflected light, presented a brownish tinge. It is sometimes difficult to distinguish this color from black, particularly in hair the care of which has been neglected. Quite often "brown" hair will appear decidedly black when thoroughly cleaned and brushed.

As chestnut we counted hair which by its coloration did not appear positively brown but which was not fair enough to be

[1] "Gesmtbericht über die von der deutschen anthropologischen Gesellschaft veranlassten Erhebungen über die Farbe der haut, der Haare und der Augen der Schulkinder in Deutschland," *Archiv für Anthropologie*, XVI, pp. 275–475.

termed blond. As this class includes many gradations of color, we have found it necessary to divide it into dark and light chestnut. Most hair here considered to be light chestnut may sometimes be taken for blond, especially when seen by direct sunlight, but close observation discloses a dark tinge. Much of the hair included in this class, shows a somewhat rufous appearance, without being decidedly red; in other instances it is almost flaxen, but with a dark tinge.

Under blond we have classed hair which is almost white, as well as the flaxen, ashen, yellowish and golden blond hair. Some of these have a more or less grayish tinge, others are even slightly rufous, while still others have no decided color at all.

There are many shades of red hair, ranging from fire-red through brownish-red to that which is almost blond but which has a decidedly rufous appearance. In doubtful cases we have been guided by other signs of erythrism, such as an abundance of freckles, and, where possible, by noting the color of the pubic hair, which is orange yellow in most cases of erythrism.

The color of the iris was observed at a distance of about one meter. Eyes showing the least degree of pigmentation were recorded as blue, but deeply pigmented eyes, with a dark bluish appearance on close observation, were not included in this class. Only eyes having no color at all or a mixture of light blue and gray were counted as blue. All dark eyes which were not decidedly black were recorded as brown. In this class are included the "beer-colored" eyes (very common among the Eastern European Jews) and those having a deep dark tint which appears dark blue on close inspection. As gray were considered all eyes which could not be included in the above two classes; it consequently includes most of those which some observers have described as green, although many of these are essentially brown. Such cases as the latter have been classed among the brown eyes. Black eyes are usually brown on close inspection, but at a distance of about a meter the iris appears deep black and shows no difference in the color of the pupil.

The color of the skin was observed in 2,272 individuals, including 1,188 men and 1,084 women. It was found to be as follows:[1]

	Jews.		Jewesses.	
Dark skin	269	22.64	276	25.46
Fair skin	919	77.36	808	74.54
Total	1,188	100.00	1,084	100.00

This indicates that Jewesses have a slightly darker skin than Jews. According to Ploss and Bartels[2] the skin of women is usually fairer than that of men.

The distribution of the color of the hair is shown in the following table:

Color of the Hair of 4,235 Jews in New York City.

Color of the Hair.	Jews.		Jewesses	
	Number.	Percent.	Number.	Percent.
Black	1,219	44.89	650	42.79
Brown	760	27.98	430	28.31
Chestnut { Dark	293	10.79	148	9.74
Chestnut { Light	191	7.03	137	9.02
Blond	165	6.08	94	6.19
Red	88	3.23	60	3.95
Total	2,716	100.00	1,519	100.00

Dividing the hair in three classes as dark, fair and red, we find the proportion to be as follows:

Color.	Jews.	Jewesses.
Dark hair	83.66	80.84
Fair hair	13.11	15.21
Red hair	3.23	3.95

These figures show that over 80 percent of the hair in Jews is dark; they also indicate that the hair of Jewesses is fairer than that of Jews, which does not agree with the results obtained by other investigators of Jewish anthropology. Talko-Hryncewicz found that among the Jews in Lithuania and Little-

[1] The figures for the Jewesses were, owing to a misprint, given as 25 percent fair skin and 74 percent dark skin (*American Anthropologist*, N. S., Vol. V, p. 92). This error is here corrected.

[2] "Das Weib," 7. auflage, 1902, p. 26; seen also Havelock Ellis, "Man and Woman," London, 1895, pp. 223–230.

Russia the proportion of dark hair in the women is 84 percent, while among men it is only 60.3 percent. Light hair was found only 16 percent in women and 39.7 percent in men.[1] Weissenberg also found that Jewesses are more brunette than Jews, but his conclusions are based on only one hundred men and forty-one women.[2] Yakowenko also determined that dark hair is more frequent among Jewesses than among Jews, only seven of the former out of one hundred having light hair.[3] This authority remarks that dark hair is more common among women than among men, while blond hair is more frequent in men. The only investigator who found the Jews to be more brunette than the Jewesses is Elkind, who found among the Polish Jews 96.81 percent with dark and 0.53 percent with fair hair, as against 86.4 percent of dark, and 8.0 percent of fair hair among Jewesses.[4]

COLOR OF THE EYES IN 4,235 JEWS AND JEWESSES.

Color of the Eyes.	Jews.		Jewesses.	
	Number.	Percent.	Number.	Percent.
Black	570	20.99	314	20.67
Brown	925	34.06	621	40.88
Gray	597	21.98	288	18.96
Blue	624	22.97	296	19.49
Total	2,716	100.00	1,519	100.00

In the appended table are given the figures of the color of the eye among the Jews investigated in New York City. It is seen that more Jewesses (61.55 percent) than Jews (55.05 percent) have dark eyes. Pure blue eyes also appear to be more frequent among the men than among the women — 22.97 percent in the former and 19.49 percent in the latter. On this point the observations of other investigators agree with those of our own.

1 Julian Talko-Hryncewicz, "Charakterystika fizyczna ludnosci zydowskiej Litwi i Rusi," *Zbior Wiadomosci do antropologii Krajowej*, XVI, pp. 17–22, Krakow, 1892.

2 S. Weissenberg, "Die südrussischen Juden," *Archiv für Anthropologie*, XXIII, p. 108 of reprint.

3 M. G. Yakowenko, "Materials for the Anthropology of the Jews" (in Russian) p. 152, St. Petersburg, 1898.

4 A. D. Elkind, "The Jews," *Publications of the Society of Friends of Natural Science, Anthropology and Ethnography*, CIV, pp. 37–47, Moscow, 1903.

Yakowenko[1] found 76 percent of Jewesses with dark eyes and only 69 percent of Jews. Of Talko-Hryncewicz's 799 Jewesses 61.8 percent had dark eyes; of his 869 Jews only 56.5 percent had dark eyes.[2] The same has been observed by Weissenberg,[3] who found 75.6 percent of dark eyes in Jewesses and only 64.8 percent in Jews. From Elkind's investigations among the Polish Jews[4] it appears that the percentage of dark eyes is about the same in both sexes.

Considering that the color of the hair and eyes is quite a stable trait, and only little, if at all, influenced by external conditions, it is of interest to investigate the proportion of fair and dark hair and eyes of the Jews grouped according to the country of their birth. If the proportion of fair-haired Jews is larger in countries where the non-Jewish population is blond, and the reverse, this may give us a clue as to the origin of the fair-haired Jews. In Table XLIV is given the percentage of Jews with a given tinge of the hair and eyes among the immigrants in New York City. It will be seen that the proportions do not materially differ from those found among the total number of 2,272 individuals considered above, especially if it is noted that the number of observations in each group is comparatively small.

The observations made that immigrants are of fairer complexion than people of the same stock who remain at home do not hold good among all Jewish immigrants. Thus, from Table XLV we see that among the Galician Jews only 15.41 percent of the immigrants have fair hair, as against 21.50 percent among the Jews in Galicia; and among the Jews who came to the United States from Lithuania and White Russia the same is true: 17.83 percent had fair hair in their native home, while only 9.82 percent of the immigrants from this region had fair hair. Of the immigrant Jews from Poland and Little-Russia the same conditions are seen to be true. The Polish Jews alone show a larger percentage of fair-haired individuals among the

[1] *Loc. cit.*, p. 158.
[2] *Loc. cit.*, pp. 24–26.
[3] *Loc. cit.*, p. 108.
[4] *Loc. cit.*, p. 52.

Table XLIV.

Color of the Hair and Eyes in Jews According to Their Nativity.

Nativity.	Color of the Hair.						Color of the Eyes.			
	Black.	Brown.	Chestnut.		Blond.	Red.	Black.	Brown.	Gray.	Blue.
			Dark.	Light.						
Galicia.										
Men.	34.76	33.77	12.45	8.19	7.22	3.61	17.05	29.83	27.54	25.58
Women.	33.61	31.14	10.66	7.28	12.29	4.92	21.31	35.25	22.95	20.49
Poland.										
Men.	49.29	27.62	8.88	5.40	5.72	3.18	21.59	35.24	21.27	21.90
Women.	42.85	37.50	8.93	5.36	1.79	3.57	26.79	30.36	32.14	10.71
Lithuania.										
Men.	48.00	32.36	5.82	5.09	4.73	4.00	22.54	33.82	25.46	18.18
Women.	44.00	30.00	6.00	4.00	9.00	7.00	29.00	27.00	24.00	20.00
Little-Russia.										
Men.	43.38	32.42	10.05	4.57	6.85	2.73	16.90	33.79	26.02	23.29
Women.	43.24	36.49	6.76	5.41	4.05	4.05	27.03	32.43	20.27	20.27
Roumania.										
Men.	49.33	29.33	4.67	7.33	7.33	2.00	18.67	30.00	31.33	20.00
Women.	36.36	29.55	18.18	6.82	6.82	2.27	18.18	31.82	25.00	25.00
Hungary.										
Men.	47.86	20.71	8.57	9.29	5.00	8.57	20.00	30.71	27.15	22.14
Women.	48.72	38.46	5.13	2.56	2.56	2.56	25.64	38.46	23.08	12.82
United States.										
Men.	35.48	37.09	12.10	7.26	4.03	4.03	20.97	34.68	24.19	20.16

Table XLV.

Color of the Hair and Eyes in Jews in the United States and in Eastern Europe.

Country.	Number Observed.	Hair.			Eyes.		Observer.
		Dark.	Fair.	Red.	Dark.	Fair.	
Galicia.							
In New York.	305	80.98	15.41	3.61	46.88	53.12	Fishberg.
In Galicia.	944	74.00	21.50	4.30	53.81	46.19	Majer-Kopernicki.
Poland.							
In New York.	315	85.70	11.12	3.18	56.83	43.17	Fishberg.
In Poland.	188	96.81	0.53	2.66	55.00	45.00	Elkind.
Lithuania.							
In New York.	275	86.18	9.82	4.00	56.36	43.64	Fishberg.
In Lithuania.	314	81.53	17.83	0.64	68.47	31.53	Yakowenko, Talko-Hryncewicz.
Little-Russia.							
In New York.	219	85.84	11.42	2.74	50.69	49.31	Fishberg.
In Little-Russia.	869	76.40	19.30	4.30	56.73	43.27	Talko-Hryncewicz.

immigrants than among those left in their native country. The proportion of fair eyes is slightly larger among the immigrants than among the Jews in their native countries, but the difference is so small as to be disregarded.

When compared with the indigenous populations of the countries in Eastern Europe in which these Jews have lived, we find that they everywhere have a larger percentage of individuals with dark hair and eyes, and a smaller of fair hair and eyes, excepting in Roumania. Thus in Galicia 75 percent of the Jews have dark hair as against only 54 percent of the Poles and Ruthenians; in Russian Poland the Poles have 78 percent with dark hair and the Jews 89 percent; the Little-Russians have 53 percent and their Jewish neighbors 78 percent; even in Lithuania and White-Russia, where the Letto-Lithuanians have only 16 percent and the White-Russians 23 percent of dark-haired individuals, there are 83 percent of such dark-pigmented Jews. The only exception is Roumania, where the Jews have only 83 percent and the Roumanians 92 percent of dark hair. The same is true of dark eyes, the Jews have a comparatively larger number of individuals with dark eyes than the indigenous population of the particular country in Eastern Europe in which they lived for centuries. On the other hand, fair hair and eyes are much more frequent among the non-Jews in these countries than among the Jews. Thus fair hair is found 20 percent among the Galician Jews as against 45 percent among the Gentiles in that country; 7 percent among the Polish Jews, and 21 among the Poles; in Little Russia, 17 percent among the Jews, and 46 among the Little-Russians; and in Lithuania, where the indigenous population is blond, the Letto-Lithuanians having 83 percent, and the White-Russians 76 percent of fair-haired individuals. Here the Jews show only 14 percent of such persons. In Roumania, we find an exception, 14.67 percent of the Jews had fair hair, as against only 6 percent among the Roumanians. Fair eyes are also more frequent among the non-Jewish populations of Eastern Europe than among the Jews as can be seen from Table XLVI; even in Lithuania, where the indigenous population has over 80 percent of fair-eyed indi-

viduals, the Jews have only 37 percent. It is significant that in countries where the percentage of fair-eyed persons is smaller than in Lithuania, the Jews, on the contrary, have proportionately more fair-eyed persons. Thus, in Galicia, where 39 percent of the Ruthenians and 70 percent of the Poles have fair eyes, the Jews have 47 percent, and in Russian Poland the Jews have 43 percent as against 81 percent among the Poles. We can consequently not find any relation between the color of the hair and eyes of the Jews and the non-Jewish populations among which they haved lived. It seems rather that the contrary is true. The Jews have almost everywhere about 80 percent of persons with dark hair, and about 50 percent with dark eyes, about 15 percent of fair hair and over 40 percent of fair eyes. The fact that the indigenous population of a country is fairer or darker does not appear to effect the Jews. This is

Table XLVI.

Color of the Hair and Eyes of Jews and Gentiles in Eastern Europe.

Country and Race.		Number Observed.	Hair.			Eyes.		Observer.
			Dark.	Fair.	Red.	Dark.	Fair.	
Galicia.								
Men.	Jews	1,248	75.80	20.03	4.17	52.12	47.88	Majer & Koper., Fish
	Poles	4,057	54.90	44.00	1.10	29.40	70.60	" "
	Ruthenians	1,356	54.20	45.80	1.40	24.90	75.10	" "
Women.	Jews	122	75.41	19.67	4.92	56.56	43.44	Fishberg.
	Poles	214	57.80	41.30	0.90	32.71	67.29	Majer & Kopernicki
	Ruthenians	133	69.90	30.10	—	45.87	54.13	" "
Poland.								
Men.	Jews	503	89.86	7.16	2.98	56.11	43.89	Fishberg, Elkind.
	Poles	226	78.37	21.62	—	18.60	81.40	Elkind.
Women.	Jews	181	87.29	7.73	4.98	56.91	43.09	Elkind, Fishberg.
	Poles	149	74.50	22.82	2.68	29.50	70.50	Elkind.
Lithuania and White-Russia.								
Men.	Jews	589	83.70	14.09	2.21	62.82	37.18	Fish., Yak., Tal.-Hr
	Let.-Lithuanians	476	16.40	83.60	0.40	13.90	86.10	Talko-Hryncewicz.
	White-Russians	961	23.30	67.70	1.00	25.40	74.60	" "
Little-Russia.								
Men.	Jews	1,088	78.31	17.74	3.95	46.32	53.68	Talko-Hryn., Fish.
	Little-Russians	2,619	52.90	45.80	1.20	25.40	74.50	" " "
Women.	Jews	873	83.39	13.63	2.98	61.63	38.37	" " "
	Little-Russians	647	64.40	33.20	2.30	42.60	57.30	" "
Roumania.								
Men.	Jews	150	83.33	14.67	2.00	48.67	51.33	Fishberg.
	Roumanians	180	92.03	6.00	1.70	64.80	35.20	Pittard.

significant, when considered in connection with the fact that many other somatic characteristics, such as stature and head-form of the Jews do greatly correspond to the type of their non-Jewish neighbors.

Typical representatives of a race show a constant interrelation between the color of their hair and that of their eyes; for example, in the blond northern races their light hair is usually accompanied by blue eyes. Individuals who do not exhibit such interrelation, having dark eyes with fair hair, or the reverse, are considered as "mixed types." From the figures in the preceding tables we find that in men 86.89 percent had dark hair (including red in this group) and 55.05 percent had dark eyes. It should therefore be expected that the combination of dark hair and dark eyes in the same individuals should occur according to the formula, $88.89 \times 55.05 \div 100 = 47.83$ percent of the individuals observed. Fair types would be expected on the same principle to occur in ($13.11 \times 44.95 \div 100 =$) 5.89 percent of Jews. In Jewesses these figures are expected to be 52.18 percent of brunettes, and 5.85 percent blonds. Empirically however we found these types to be distributed in the following proportions:

Table XLVII.

Types of Pigmentation in 4,235 Jews.

Type.	Jews.		Jewesses.	
	Number.	Percent.	Number.	Percent.
Brunette	1,495	52.62	865	56.94
Blond	283	10.42	156	10.27
Mixed	1,004	36.96	496	32.79
Total	2,716	100.00	1,519	100.00

From this table we find that in 52.62 percent of all Jews observed both hair and eyes were dark; the combination of fair hair and eyes was observed in 10.42 percent of Jews and 10.27 percent of Jewesses. The brunette type which is considered characteristic of the Jews, is thus reduced to only 52 percent in the contemporaneous Jews, and to 57 percent among the modern Jewesses. But when we recall that other races of

Europe show even a smaller percentage of their racial type combination, we are not surprised. In Germany, among 6,000-000 school children only 31.80 percent had both blond hair and blue eyes, while of the 75,377 Jewish children 42 percent were of the pure brunette type.[1] In Austria Schimmer has found that of the non-Jewish children 19.79 percent were of pure blond type, and 23.17 percent of the brunette type, while Jewish school children showed a percentage of from 32 to 47 of pure brunettes according to the province, and from 8 to 14 percent of pure blonds.[2] That the Jews have apparently not preserved themselves free from intermixture can be seen from the number of mixed types found among them. 37 percent of Jews and 33 percent of Jewesses had dark hair with light eyes, or the reverse; Weissenberg[3] found 27.9 percent of mixed types; Yakowenko[4] observed 67.31 percent and Majer and Kopernicki, 61 percent.[5] Talko-Hryncewicz,[6] records even 74.3 percent of mixed types among 869 Jews in Little-Russia, and in Poland there were 41.53 percent according to Elkind.[7] In addition, the great number of individuals with blond and light chestnut hair, irrespective of their association with light or dark eyes, which reached 13.11 percent in men and even 15.21 percent in women in New York City, also indicate foreign intermixture, and the same can be seen from the number of blue and gray eyes, amounting to 44.95 percent in Jews and 38.45 percent in Jewesses. All this again points to racial intermixture.

That we can get no clue as to the origin of these mixed types by a consideration of the color of the hair and eyes of the Jews in different countries we have already seen. The Jews are not

[1] Virchow, "Gesamtbericht, über die Farbe der Haut, der Haare, und der Augen," etc., *Archiv für Anthropologie*, XVI, p. 298.

[2] G. A. Schimmer, "Erhebungen über die Farbe der Augen, der Haare und der Haut bei den Schulkindern Oestreichs," *Mittheilungen der Anthropologischen Gesellschaft in Wien*, Suppl., 1884.

[3] *Loc. cit.*, p. 107.

[4] *Loc. cit.*, p. 45.

[5] Majer and Kopernicki, "Charakterystyka, fizyczna ludnosci galicyjskiej," *Zbior Wiadomosci do antropologii Krajowej*, Vol. I, p. 111, Krakow, 1877.

[6] *Loc. cit.*, p. 45.

[7] *Loc. cit.*, p. 39.

necessarily more blond in countries where the indigenous population is blond, the reverse is rather true. A study of the interrelation of the color of the hair and eyes into types gives the same results, as can be seen from the following table :

TABLE XLVIII.

TYPES OF PIGMENTATION OF JEWS IN VARIOUS COUNTRIES.

Nativity.	Type.			Number Observed.	Observer.
	Dark.	Fair.	Mixed.		
Galician Jews.					
Men, in New York..........	43.93	13.12	42.95	305	
Women, in New York........	50.82	16.39	32.79	122	
Polish Jews.					
Men, in New York..........	53.65	9.52	36.83	315	
Women, in New York......	50.00	5.36	44.64	56	
Men, in Poland.............	57.92	0.55	41.53	183	Elkind.
Women, in Poland..........	58.50	8.50	33.00	118	"
Lithuanian, White-Russ. Jews.					
Men, in New York..........	53.09	8.73	38.18	275	
Women, in New York	53.00	12.00	35.00	100	
Men, in Lithuania...........	63.06	10.19	26.75	314	Yakowenko, Talko-Hryncewicz.
Women, in Lithuania........	74.00	6.00	20.00	100	Yakowenko.
Little-Russian Jews.					
Men, in New York..........	49.31	7.31	43.38	219	
Women, in New York........	55.41	8.11	36.49	74	
Men, in Little-Russia........	51.30	16.20	34.00	869	Talko-Hryncewicz.
Women, in Little-Russia...	68.60	6.90	24.30	799	" "
Roumanian Jews.					
Men, in New York..........	46.67	10.66	42.67	150	
Women, in New York......	50.00	13.64	36.36	44	
Hungarian Jews.					
Men, in New York..........	45.71	12.14	42.15	140	
Women, in New York	61.54	5.13	33.33	39	
United States.					
Men, in New York..........	50.81	8.87	40.32	124	

From this table it is seen that the proportion of dark types oscillates between 44 percent (Galician) and 53 percent (Polish and Lithuanian Jews). Fair types were encountered 7.31 percent among the Little-Russian, 8.73 among the Lithuanian and White-Russian, 9.52 among the Polish, 10.66 among the Roumanian, 12.14 among the Hungarian, and 13.12 percent among the Galician Jews. A comparison with the Jews in their native

countries does not reveal any process of selection of fair types among the immigrants, as can be seen from Table XLVIII. Excepting the Polish Jews, those observed in Eastern Europe have a larger proportion of blonds than those who emigrated to the United States.

TABLE XLIX.

TYPES OF PIGMENTATION AMONG JEWS AND NON-JEWS IN EASTERN EUROPE.

Country and Race.	Number. Observed.	Type. Dark.	Fair.	Mixed.	Observer.
Poland.					
Jews, men	275	55.22	6.23	38.55	Elkind, Fishberg.
" women	174	55.75	7.47	36.78	" "
Poles, men	226	17.57	20.27	62.16	Elkind.
" women	149	25.50	20.81	53.69	"
Lithuania and White-Russia.					
Jews, men	589	58.41	9.51	32.08	Yakowenko, Talko, Fishberg.
" women	200	63.50	9.00	27.50	Yakowenko, Fishberg.
Letto-Lithuanians, men	476	5.00	66.60	28.40	Talko-Hryncewicz.
White-Russians, men	961	11.50	57.10	31.30	" "
" " women	275	21.09	58.55	20.36	Shtchedrobitzki (Ivanovski).
Little-Russia.					
Jews, men	1,088	51.84	14.43	33.73	Talko-Hryncewicz, Fishberg
" women	873	67.69	6.99	25.32	" " "
Little-Russians, men	2,619	20.40	34.00	45.60	" "
" " women	647	24.70	36.90	38.30	" "

A comparison of the Jews with the races and peoples in Eastern Europe among which they have lived shows that the proportion of fair types among the Jews does not depend upon the frequency in which these types are encountered among the non-Jews. From Table XLIX it is evident that even in Lithuania and White-Russia, where the indigenous population has up to 66 percent of persons with fair hair and eyes combined in the same individuals, the Jews have only 9.51 percent of such persons, while in Little-Russia, where the indigenous population is darker, having only 34 percent of fair types, the Jews on the contrary have a much larger percent of fair types, 14.43 percent.

This condition has already been observed to be true of the German, Austrian and Hungarian Jews. In his investigation of the color of the skin, eyes and hair of the school children in Germany, Virchow found the proportion of brunettes to be

larger in the provinces where the non-Jewish population is fairer. This can be seen from the following table taken from Virchow's work :

Province.	Blonds.		Brunettes.	
	Jews.	Christians.	Jews.	Christians.
Prussia	11.23	39.75	43.34	9.29
Hessen	11.17	31.53	41.50	13.22
Baden	10.32	24.34	41.95	21 18
Bavaria	10.38	20.36	39.45	21.10
Alsace-Lorraine	13.51	18.44	34.59	25.21

These figures shows in a striking manner that in the provinces of Germany, where the percentage of brunettes is smallest among the Christian population, in Prussia only 14.05 percent, the Jews have 42.34 percent of brunettes, the highest percentage ; while in Alsace-Lorraine and Bavaria where the Christians have 25.21 and 21.1 percent respectively of brunettes, the Jews have only 34.59 and 39.45 percent of such persons. A consideration of the color of the eyes of the school children in Germany gives the same results :

	Percent of Fair Eyes.		Percent of Dark Eyes.	
	Jews.	Christians.	Jews.	Christians.
Prussia	18.7	43.0	53.5	24.3
Bavaria	20.0	29.0	49.0	49.0

Where the proportion of fair eyes among the Christians is large, as in Prussia, the Jews have only 18.7 percent, while in Bavaria, where only 29 percent of the non-Jewish children had fair eyes, the Jewish had 20 percent. This is more strikingly confirmed by considering the distribution of the pure blond and brunette types among the Jews in Germany and Austria from Virchow's and Schimmer's works.

Germany.	Pure Blonds.	Pure Brunettes.
Silesia	8.20	49.53
Pomerania	8.85	50.58
Brandenburgh	9.64	47.39
East and West Prussia	11.61	43.04
Posen	12.39	39.22

Austria.	Pure Blonds.	Pure Brunettes.
Bohemia	8.29	46.87
Lower Austria	8.69	46.16
Moravia	9.86	43.15
Bukowina	13.55	35.21
Galicia	13.97	32.91

It is evident from these figures that the farther we go south and east of Europe, the smaller the proportion of brunettes among the Jews, and the larger the proportion of blonds. With the non-Jewish population of this region the reverse is the fact, as can be seen graphically from the maps prepared by Virchow and Ranke.[1] Most of the blonds are found in Prussia, Pomerania, Sleswick-Holstein, Hanover, Westphalia, etc., and the farther east we proceed reaching Posen, Silesia, Bohemia, Moravia, Upper and Lower Austria, and finally the Bukowina and Galicia, the percentage of pure blonds decreases, and the brunettes increase in frequency. It is noteworthy, as has been pointed out by Virchow, that in localities where the Jews have lived for centuries in strict isolation from other races, owing to religious and social prejudices, and presumably did not intermarry with their Gentile neighbors, the proportion of blond types is larger than in the Prussian provinces where they are not socially isolated but on the contrary have entered into general social intercourse with the non-Jewish inhabitants. Here the largest proportion of brunette types is found among the Jewish school children.

This fact, which is fully confirmed by our observations on the immigrant Jews in the United States, is of peculiar significance, particularly when considered in connection with the fact that other somatic traits of the Jews depend greatly on the characteristics of their non-Jewish neighbors.

The high percentage of red-haired Jews is interesting. Among the Jews in New York we found that 3.23 percent of the men, and 3.95 percent of the women had red hair. Majer and Kopernicki, Weissenberg and Talko-Hryncewicz find 4 percent of red-haired Jews, and indeed erythrism has been regarded as characteristic of the Jews, both in Europe and the Orient. We find that the red hair, particularly the beard, is usually frizzly and nearly always accompanied by freckled skin. This erythrism appears not to be of recent origin; it was not unknown among the ancient Hebrews, for Esau was said to have been "red all

[1] *Der Mensch*, Vol. II, p. 290; reproduced in Ripley's "Races of Europe," p. 222.

over like a hairy garment."[1] The reference to David as "ruddy" is explained by the Targum as "red-haired." Jacobs[2] comments on this as showing that the Jews of the time when the Targum was written (about 600 A. D.) where not averse to regarding the typical Jewish king as rufous. Painters in the early centuries of this era represented Christ with light hair, and Mary Magdalene is almost always depicted as having light hair. Judas Iscariot is considered to have been a typical red-haired individual, although the New Testament makes no mention of it. Besides this it must be mentioned that in ancient Egyptian monuments the Canaanites are pictured as having red hair and red beards. The Edomites, if we may trust the etymology of the word "edom," were also red-haired. The red hair of the modern Jews is thus considered by many archeologists to be derived from the ancient red-haired individuals and races in Palestine in ancient times.

The hair of the beard in men is usually lighter than that of the head, and red beards are more frequent than red heads. Observations on the color of the beards of 587 Jews show the following distribution:

Color.	Number.	Percent.
Black	175	29.82
Brown	118	20.10
Chestnut	81	13.80
Light chestnut	34	5.79
Blond	115	19.59
Red	164	10.90
Total	587	100.00

From these figures we find that red hair is nearly three times as common in the beard as in the hair of the head. This is not at all surprising to any one who has observed the Jews closely for the beard is quite frequently red and very often has at least a rufous tinge of frizzly character. I find that red beards are more frequently found among the Jews of Galicia than among those of other countries. Besides the red beards we find from

[1] Genesis, XXV, 25.
[2] *Journal Anthropological Institute*, XV, pp. 23–62.

the table that 25.38 percent of Jews had fair-colored beards, nearly double the proportion of those with fair heads.

We have distinguished four varieties of hair; (1) Smooth (*Schlicht* in German, *droit* in French); (2) Wavy (*wellig* in German, *ondé* in French); (3) Frizzly (*lockig* in German, *frisé* in French); (4) Wooly (*Kraus* in German, *crépu* in French). Observations on 867 men showed the following distribution in the varieties of hair:

Smooth hair	582 =	66.97 percent.
Wavy hair	223 =	25.66 percent.
Frizzly hair	55 =	6.33 percent.
Wooly hair	9 =	1.04 percent.

Weissenberg found 88 percent of smooth, 14 percent of wavy, and 2 percent of frizzly hair. From our own figures it is seen that 93 percent of the hair of Jews is either smooth or wavy, and that frizzly hair is rare (6.33 percent). Weissenberg[1] found only two curly-haired Jews among 100, and Major and Kopernicki[2] found only one curly-haired individual in 118, or 0.84 percent. Yakowenko[3] found four percent with curly hair, and Glueck among the Spagnuoli states that he observed as much as 47.1 percent of curly and frizzly hair.[4] In Weisbach's study of the Jews of the Balkan peninsula, there are recorded 10 in 19 as having curly hair.[5] These last are of course rather a too high percentage, not borne out by any other investigation, and the only way in which it can be explained is that it is due to chance, owing to the small number of individuals observed (55 by Glueck, and 19 by Weisbach), or to judging the variety by the appearance of the beard which is very frequently frizzly, in Jews; indeed the rufous beards are almost always frizzly and the black are often of the same character. We have emphasized this characteristic smoothness of the hair in the

[1] *Loc. cit.*, p. 103.

[2] *Loc. cit.*, p. 115.

[3] *Loc. cit.*, p. 153.

[4] L. Glueck, "Beiträge zur physischen Anthropologie der Spaniolen," *Wissenschaftliche Mittheilungen aus Bosnien und der Hercegovina*, Vol. IV, pp. 587–592.

[5] A. Weisbach, "Körpermessungen Verschiedener Menschenrassen," *Zeitschrift für Ethnologie*, Ergänzungsband, 1877, pp. 212–225.

modern Jews, because of the fact that many of the contemporaneous non-Jewish Semites, are known by their frizzly and wooly hair as much as by any other somatic characteristic.

Pigmentation undergoes changes with the advance of the age of the individual. Grayness, or *canities*, may be premature or senile. Up to the age of 35 or 40 years the hair retains its normal color with most people. If grayness occurs before that time, it is considered premature; otherwise it is considered to be normal or senile. We have noted grayness in 161 individuals over 20 years of age, being 18.52 percent of the total 867. The youngest individual with gray hair was 22 years of age; the oldest retaining the natural color of his hair was 46 years of age. Weissenberg thinks that grayness appears quite early in Jews, while Yakowenko shows that it appears rather late, or about the age of 45 years. From our own observations we do not think that the Jews show any marked differences in this respect from other civilized peoples. Of the 161 gray-haired individuals examined, only 28 were younger than 35, a proportion which can not be regarded as abnormal.

Baldness, or alopecia, due to arrested development of the pilary system, is another change in the hair which appears with advanced age. It normally appears at about the age of 45 years, when other signs of decay become manifest, as grayness, loosening or decay of the teeth, dimunition of the keenness of sight, etc.; under these circumstances it is called *alopecia senilis*. On the other hand, *alopecia prematura* takes place at an earlier age, and is more frequent in brain workers and in those leading sedentary occupations or exposed to prolonged mental worry. Many writers have stated that this change takes place earlier in Jews than in non-Jews. Weissenberg[1] has found that 16 percent of Jews between the ages of 21 and 50 years presented more or less baldness, the youngest showing this change being 23 years of age. Yakowenko[2] on the other hand, shows that baldness is exceptional in Jews younger than 46 years, and when it occurs before this age it is usually due to favus. From

[1] *Loc. cit.*, p. 103.
[2] *Loc. cit.*, p. 32.

our investigations we are inclined to agree with Yakowenko. Excluding alopecia due to favus we have found 83 individuals with more or less baldness among 1,188 over 20 years of age. The youngest was 26 years. Only 12 individuals younger than 40 were affected with baldness.

Freckles (*ephelides*) was noted in all the red-haired individuals, and those having swarthy skin are also very often affected with freckles. Of 74 men and 62 women with light hair observed, only 4 men and 2 women were freckled.

CHAPTER VIII.

The Combination of Traits Into Types.

The North-European (or so-called "Aryan") type, *i. e.*, the combination of blond hair, blue eyes, tall stature and dolichocephaly, is not to be observed among the Jews. Taking up first the relation of stature to the shape of the head, we find that tall individuals are not more longheaded than those of short stature. In fact there is no difference at all in the head-form according to stature, as can be seen from the following figures :

Stature.	Average Width of Head.	Average Length of Head.	Cephalic Index.
Short	153	186	82.26
Below the average	154	187	82.35
Above the average	154	188	81.91
Tall	156	190	82.11
Average	154	188	81.91

In the same manner the head-form and pigmentation does not show any relation between longheadedness and blondness. It was found that the average cephalic index of 86 blond individuals was 81.35, and of the dark-haired Jews, 81.97, almost identical. The various types of head-form were found in the blonds and others in the following proportions :

Type of Head.	Blond-Haired Jews (Percent).	Others (Percent).
Hyperdolichocephalic	3.49	2.84
Dolichocephalic	5.81	7.42
Subdolicocephalic	8.14	15.88
Mesocephalic	33.72	25.31
Subbrachycephalic	20.93	24.20
Brachycephalic	20.93	15.81
Hyperbrachycephalic	6.98	8.53
Number observed	86	1,442

From this table it is to be seen that 9.30 percent of the blonds were dolichocephalic (cephalic index 77 and less), while the dark-haired individuals had even slightly larger percentage of

dolichocephalic — 10.26. Brachycephalic men (cephalic index 84 and upward), were found among the dark-haired, 24.34 percent, and among the blonds, the percentage was much larger, 27.91 percent. This does not confirm the observations of Majer and Kopernicki[1] who found that among the brunette Jews in Galicia 6.2 percent are dolichocephalic, as against 20 percent of the blond Jews being of this type of head-form. This has often been quoted in support of the theory that the blond Jews have their origin in "Indo-Germanic" infusion.

The relation of the color of the eyes and the head-form is seen from the following table:

TABLE L.

COLOR OF THE EYES AND HEAD-FORM.

Type of Head-Form.	Color of the Eyes.		
	Blue.	Gray.	Dark.
Hyperdolichocephalic	3.26	3.08	2.50
Dolichocephalic	7.69	7.20	7.61
Subdolichocephalic	12.13	14.65	16.98
Mesocephalic	26.63	24.17	26.34
Subbrachycephalic	24.26	24.94	23.35
Brachycephalic	18.93	14.14	15.73
Hyperbrachycephalic	7.10	11.82	7.94
Number observed	338	389	801

The average cephalic index was found in the

Blue-eyed individuals	81.43
Gray-eyed individuals	81.58
Dark-eyed individuals	81.96

which is almost identical in the three classes. From the above table we also see that the percentage of dolichocephalic Jews was among the blue-eyed, 10.95; in gray-eyed, 10.28, and in the black and brown-eyed, 10.21, about the same in every group. Of brachycephalics we found among blue-eyed Jews, 26.03 percent; among gray-eyed, 25.96, and among dark-eyed, 23.22 percent. This again shows that dark-eyed individuals are like dark-haired Jews, less brachycephalic than fair-eyed Jews.

[1] *Loc. cit.*, pt. I, p. 132.

The relation of pigmentation to stature has been studied by Pantukhof, who found that in Odessa, Russia, the Jews who had dark hair and eyes are of short stature, while those who have gray or blue eyes and fair hair are taller.[1] The same observer reports that among the Jews in Caucasia he found that those who are tall in stature have usually light eyes; those who have brown eyes were 161.7 cm. in height, while those who have blue or gray eyes averaged 164.4 cm.[2] On the other hand[3] Ammon found no relation between blond hair, blue eyes, and dolichocephaly among the Jewish recruits in Baden, Germany. Elkind reports the same of the Jews in Russian Poland, and finds that those who have dark hair and eyes are even taller than those with fair hair and eyes.[4] Our own measurements confirm this more strongly, because they are based on a larger number of observations.

Taking the relation of stature to pigmentation we find no "Teutonic" or "Aryan" association:

Stature.	Blond Hair.	Dark Hair.
Short	22.09	23.37
Below the average	31.39	30.03
Above the average	25.59	27.60
Tall	20.93	19.00
Average stature	163.8	164.6

From these figures it is to be seen that the dark-haired Jews were taller, 164.6 cm. in height, than those who had blond hair, the latter averaging only 163.8 cm. in height. The proportion of tall and short people is about the same in both the blond-haired as in the dark-haired individuals. The same is seen from the figures on page 281, where the relation of the color of the eyes to stature is given. The average height of those having brown or black hair is 165.1 cm. as against only

[1] "Semitic Types," *Proc. Russian Anthropological Society*, pp. 26–30, St. Petersburg, 1889 (in Russian).

[2] *Idem.*, "Observations anthropologiques au Caucase" (in Russian), pp. 37–38, Tiflis, 1893.

[3] Otto Ammon, *Zur Anthropologie der Badener*, pp. 663, 664, Jena, 1899.

[4] D. N. Elkind, "The Jews," *Memoirs of the Soc. of Friends of Natural Science, Anthropol. and Ethnography* (in Russian) CIV, 1902, pp. 82–83.

163.8 of those who had blue or gray eyes. The proportion of tall individuals (over 165 cm. in height) is 48.44 percent among dark-eyed Jews and only 45 percent in those with light eyes. Short people (less than 165 cm. in height) are found only in the proportion of 51.56 percent among those with dark eyes, and reach 55.92 percent in those with blue eyes.

	Color of the Eyes.		
Stature.	Blue.	Gray.	Dark.
Short	22.78	25.44	22.47
Below the average	33.14	29.57	29.09
Above the average	26.33	25.45	28.97
Tall	17.75	19.54	19.47
Average stature	163.8	163.8	165.1
Number observed	338	389	801

From all these figures we find that the ideal "Aryan" combination of stature, pigmentation and head-form is not to be observed among the Jews. On the contrary, the rule among them appears to be that the tall people have darker hair and eyes, and have a lesser percentage of dolichocephalic individuals; and that those who are short of stature are of fairer complexion, and show a larger percentage of dolichocephalic persons. This tends to exclude the "Aryan" influence as a cause of the Jewish blonds, but it must be emphasized that this condition does not by any means exclude Slavonic infusion, for it has namely been observed that among the various Slavonic peoples, tall stature is often combined with dark hair, and shortness of stature with blond hair. This is the case, according to Weisbach's researches, with the Serbo-Croats.[1] Among the Poles also the the brunettes are taller than the blonds;[2] also among the White-Russians;[3] and the Great-Russians[4] Vorob'eff concludes that among many Slavonic peoples, such as the Serbo-Croats,

[1] A. Weisbach, "Die Serbo-kroaten der adriatischen Küstenländer," *Zeitschrift fur Ethnologie*, 1884, Supplement.

[2] Elkind, *loc. cit.*, pp. 363–364.

[3] E. R. Eicholtz, "Materials for the Anthropology of the White-Russians" (in Russian), St. Petersburg, 1896.

[4] V. V. Vorob'eff, "Materials for the Anthropology of the Great-Russian Population," etc., *Memoirs Anthropological Section*, Vol. XIX, 1899, pp. 59, Moscow (in Russian).

Czechs, Poles, Ruthenians, Little-Russians, White-Russians, etc., the rule is, the larger the percentage of brunettes, having dark hair and eyes, the larger the proportion of tall and round-headed individuals.[5] A glance at the ingenious maps prepared by Ripley[1] showing stature and cephalic index in Eastern Europe, confirms this graphically. The Slovaks, Little-Russians, Serbo-Croats, Servians, etc., are taller, and also more brachycephalic than the Poles, Great-Russians, etc. Another confirmation of this view is to be found among Great-Russians in Transbaikalia, Siberia, who emigrated thither in the Seventeenth Century, and are considered to have preserved their Slavic type more free from intermixture. They are taller, and also more brachycephalic than their brethren in European Russia.[2]

All this evidence shows that the "Slavonic type" does not at all agree with the so-called "North European" or "Aryan" type, in which fair complexion is combined with tall stature and dolichocephaly, but that the reverse appears to be true — tall stature is combined with wide heads and brunettes and the reverse. We may consequently look for the cause of the blondness among twelve percent of the modern Jews as possibly due to Slavic intermixture. From all available data we find that the interrelation of stature, pigmentation and head-form, are similar to those which are normal in the Slavic populations among which these Jews have lived for centuries.

[1] V. V. Vorob'eff, "On the Study of the Anthropology of the Slavic Population of Russia," *Russian Anthropological Journal*, 1902, No. 2, p. 106; and also "The Great Russians," *ibid.*, 1900, No. 1, pp. 43–82.

[6] "The Races of Europe," pp. 340 and 350.

[2] J. D. Talko-Hryncewicz, "The Anthropology of the Great-Russians of Transbaikalia," Tomsk, 1898 (in Russian).

CHAPTER IX.

Conclusion.

As was stated in the introduction, the most important problem presented by the study of the physical anthropology of the Jews is whether they have maintained their racial purity during centuries of dispersion in various parts of the world. It would be desirable in this connection to compare the physical traits of the modern Jews with those of the ancient Hebrews, which is at the present impossible. The ancient Hebrews have not embalmed their dead, and consequently no skeletons have been found thus far in Palestine, dating back to the period of the Jewish reign in that country. One thing is certain, however, the original stock of the Jews was not made up of a single and homogeneous race, as is supposed by some. There are many references in the Bible to intermarriages of the ancient Hebrews with other non-Jewish races, as the Hittites, Amorites, Cushites Canaanites, etc. That some of these races were not of Semitic stock has been established recently by archeological research. The Amorites, for instance, are believed to have been "Aryans," tall, blond and dolichocephalic; and a considerable amount of evidence has been brought forward in support of this theory.[1] The Hittites are considered by some to have been a Mongoloid race, by others brunette brachycephals of the so-called Armenoid type.[2] The Cushites, according to Biblical and other evidence, were Negroes.[3] The ancient Hebrew patriachs and the aristocracy of Israel have freely indulged in intermarriage with these and other non-Jewish races, and it can safely be assumed

[1] See A. H. Sayce, "The Races of the Old Testament," London, 1891; also Luschan, *loc. cit.*

[2] See M. Alsberg, "Rassenmischung im Judenthum," Hamburg, 1891; Lus chan, *loc. cit.* Sayce, *loc. cit.*

[3] May the negroid traits such as dark skin, thick lips, prognathism, wooly hair, etc., which are often met with among the modern Jews, not be cases of atavism?

that the common people followed the example. All this shows that the Jews cannot, even during their most glorious period of their history, be considered to have been a pure race free from foreign blood in their veins.

A comparison of the Jews with the living non-Jewish Semitic tribes shows that they belong to totally different races of mankind. The Bedouin Arabs, who are said to have preserved themselves in the purest state are of a totally different type than the modern Jews. They are of dark complexion, and it is very rare to find an Arabian with a fair skin, blond hair and blue eyes. They are above the average stature, averaging 166 to 168 cm. in height. Their headform is distinctly dolichocephalic, with an average cephalic index of 73 to 77. All this shows that the modern non-Jewish Semites are of distinct African type. The Jews on the other hand are of an Asiatic type, short of stature, brachycephalic, and in addition present a large proportion of blonds. In fact if the Bedoins are considered the standard Semitic type, then the Jews are not Semites at all. All the measurements taken on modern Jews tend to prove that physically they possess traits akin to those presented by the races and peoples among which they have lived during the last thousand years. The Jews are taller than in countries where the non-Jewish population is tall, and the reverse. In our study we found that stature is considerably influenced by environment, social and economic conditions. But the environment theory does not explain satisfactorily why the Jews in the Bukowina are taller than those in Galicia, or why the Jews in Russian Poland are shorter than those in Little-Russia. It is well known that economic and social conditions of the Jews in the Bukowina are not superior to those in Galicia; or that in Little-Russia the Jews are employed more often in outdoor occupations than in Russian Poland; nor is it known that the climate of Roumania, Little-Russia and the Bukowina is especially favorable to growth of the body. The fact that almost everywhere the Jews are shorter by about two to three centimeters on the average than the Gentiles of the same country accounts for the effects of environment and peculiarity of social

conditions to a certain extent. It also proves that poverty, privation and underfeeding could only reduce a few centimeters of their height, but was not potent enough to deface the effects of race; could not make the Jews in every country of about the same average height. It is therefore safe to explain these differences in stature of the Jews, as caused by the infusion into their veins of non-Jewish blood. All the evidence available tends to exclude environment as the sole cause, and that intermarriage, open or clandestine with non-Jews, accounts for the fact that the Jews in Little-Russia, Bukowina and Roumania, etc., taller than the Jews in Galicia, Poland, etc. They are taller in the named countries because the indigenous races in the named countries, the Little-Russians, Ruthenians, Roumanians, etc., are taller. How far this holds good can be seen from Table VIII showing the stature of the Jews in various Eastern European countries, and in the diagrams showing the curves of these figures. It is also attested by the figures in the same table showing the distribution of the classes of stature among Jews and non-Jews. As long as it can not be conclusively proven that the Jews in Roumania and Little-Russia are more often engaged in outdoor occupations, or are economically superior to those in Galicia and Poland, we will find the best explanation for the fact that the larger percentage of tall Jews in the former countries, and the larger percentage of short Jews in the latter, as due to intermixture with the native races.

While the effects of environment are to be considered while speaking of stature, this is a negligible quantity in the case of the headform. Extensive craniological research has conclusively shown that the shape of the head depends only on race and heredity. Neither climate, nor social, nor economic conditions appear to have any influence on the cranial type. Wherever heterogeneity of the cephalic index has been found in a group of people, it was mostly found that racial intermixture was the cause. As was shown in chapter IV the type of head of the Eastern European Jews is mesocephalic, about the same as that of the races and peoples of the countries in which they live. Wherever the head of the indigenous population is

broader, that of the Jews is also wider, and the reverse. When to this is added that in Caucasia the Jews have hyperbrachycephalic and in North Africa they are dolichocephalic, corresponding to the type found among the non-Jewish population, the reason for the diversity of type is apparent.

The headform of the ancient Hebrews is not known, because there are no crania available for measurement. The oldest Jewish skulls were measured by Lombroso.[1] They were found in the catacomb of Saint Calixtus in Rome, and date back to 150 A. D. The cranial indices of five of these skulls are 80, 76.1, 78, 83.4, and 75.1, which means an average cephalic index in the living of 80.5. It is understood that no definite conclusions can be drawn from measurements of only five skulls, but the fact that among these are found not one dolichocephalic, and two brachycephalic skulls, points strongly against the opinion that the ancient Hebrews were a purely dolichocephalic race, corresponding to the type of the modern non-Jewish Semites. In this connection, Luschan's theory is of interest. He suggests that the greater part of the ancient Hebrews were derived from the Hittites, a brachycephalic race which flourished in Syria and Asia Minor about 1500 B.C. Their decendants in modern times are shown by the same authority, and also by Jensen,[2] to be, besides the Jews, also the Armenians, the Turks, the Greeks and others. Luschan points out that even the physiognomy of the modern Armenians, particularly the arched and aquiline nose, considered at the present to be peculiarly Jewish, is in fact, Armenian, and the same is true of other traits, such as pigmentation, etc. If this were true, then the Jews in the Caucasus are the ones who preserved the original type more than any other group, and those in other countries are the ones who diverted from the type. Not all the living Semites are dolichocephalic. Chantre shows that the contemporary Syrians of Semitic speech are often as brachycephalic as the Armenians. The same headform is characteristic of the Semites in the Caucasus, such as the Lesghians, Georgians, Aïsores, etc. Pan-

[1] "L'antisemitismo e le scienze moderne," Torine, 1894, appendix.

[2] "Hittiter und Armenier," p. 63.

tukhof shows that these races are of Semitic origin.[1] Considering that the Jews are not recent arrivals, but have been there from time immemorial, the headform of the ancient Hebrews' skull may have been brachycephalic. In support of such a theory can be cited measurements of twelve skulls from a Jewish cemetery, in Basle, Switzerland, dating back to the thirteenth and fourteenth centuries.[2] The average *cranial* index of these skulls is 84.66, *i. e.*, a *cephalic* index on the living of 86.66, which is about the same as that of the Jews in Caucasia. While twelve skulls are by far not sufficient to lead to definite conclusions, still, the fact that not one of these skulls is dolichocephalic, is of great significance. It tends to show that the headform of the Jews in Europe has during the last few centuries elongated, and not become rounder.

But no matter whether the original type of skull of the Jews was brachycephalic or dolichocephalic, the majority of the modern Jews in Europe are mesocephalic as has been shown above. That intermarriage of races with different cranial types will produce a middle type, has recently been disproved. The prevailing opinion at the present is that intermarriage of long- with round-headed races, does not produce middle types, but the continued coëxistence of both types. Professor Boas's studies on the North American Indians shows this to be true. This was also found to be true of the Eastern European Jews.[3] The fact that the hyperbrachycephalic and dolichocephalic types of head are so infrequently found among the Jews in Eastern Europe may thus be explained that intermarriage with the native races has by a process of natural selection eliminated these two types, giving place to the headform of the latter; and that the headform of the Jews does exactly correspond to that of their non-Jewish neighbors, is a good proof pointing in this direction.

[1] I. I. Pantukhof, "Observations anthropologiques au Caucase," and also "Les races du Caucase," Tiflis, 1900.

[2] J. Kollmann, "Schädel und Skeletreste aus einem Judenfriedhof des 13. and 14. Jahrhundert zu Basel." *Verhandl. der naturforschenden Gesellschaft*, Basel, 1885, VII, pp. 648-656.

[3] Franz Boas, "Heredity in Head Form," *American Anthropologist*, N. S., V, 1903, pp. 530–538.

The origin of the blond Jews is another problem which is of interest. Judging from Biblical tradition, and the race portraits of the ancient Assyrian and Egyptian monuments, there were blond Jews in antiquity. At present over 10 per cent. of Jews have blond hair, and in some countries even 20 per cent. Some believe that these blond Jews are the descendants of cross marriages of ancient Hebrews with Amorites. The fact that in Caucasia, where the indigenous population is dark, only 2 per cent. of the Jews have fair hair (Pantukhof) is against it. It may be good evidence that in Caucasia, the Jews, even had they intermarried with the indigenous races, could not acquire blond hair. The only possible objection that could be found against the opinion that the blond Jews in Europe are derived from intermarriage with North European races, is the fact emphasized in chapter VI. that they are more blond in countries where the indigenous population is darker and the reverse. But it must be acknowledged that it makes very little difference where they have acquired it, as long as it is agreed that this blondness is one of the best proofs that they have not maintained themselves in as pure a state as is generally supposed. That it cannot entirely be ascribed to intermarriage with the Amorites and other fair races of Palestine in Biblical times, is attested by the fact that the modern Jewish blonds are not taller, nor more dolichocephalic than the brunettes. Archeological research has shown that the blond Amorites were dolichocephalic and of tall stature, the Hebrews, compared with them were as "grasshoppers in their own sight."[1] The brunette Jews in Eastern Europe correspond to the Slav type, being taller and having longer heads. This is normal among the Slavonians, such as the Poles, Czechs, Ruthenians, Little-Russians, White-Russians, etc., as has been shown in Chapter VIII. Nobody claims that the ancient Hebrews have come in contact with these races before their dispersion. This trait could only have been acquired while the Jews have lived among the Slavonians in Eastern Europe, during the last ten centuries.

We conclude that the bulk of the modern Jews, who live at

[1] Numbers XIII, 33.

the present in Eastern Europe, and who constitute over 80 per cent. of all the Jews, are physically more akin to the races among which they have lived in Eastern Europe, than to the so-called Semites.

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CONTENTS.

[Annals N. Y. Acad. Sci., Vol. XVI, No. 7, pp. 299–386, Aug. 2, 1905.]

RECORD OF MEETINGS

OF THE

NEW YORK ACADEMY OF SCIENCES.

January, 1904, to December, 1904.

Henry E. Crampton, *Recording Secretary.*

BUSINESS MEETING.

January 4, 1904.

The Academy met at 8-15 P. M., President Wilson presiding. In the absence of the secretary, the reading of the minutes was dispensed with.

There being no business to come before the meeting, the Academy then adjourned.

Charles Lane Poor,
Secretary pro tem.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

January 4, 1904.

Section met at 8:15 P. M., Vice-President Poor presiding. The minutes of the last meeting of the Section were read and approved.

The following program was then offered:

Herschel C. Parker, Altitude Observations with the Hypsometer in the Canadian Rockies.

George F. Kunz and Charles Baskerville, Phosphorescence in Diamonds Produced by Pitchblende.

Bergen Davis, Latest Theories Relating to the Discharge of Electricity in High Vacua, and Ionization of Gases.

Summary of Papers.

Professor **Parker** presented a brief outline of the various methods used in altitude determinations, showing that all are based on two general methods, triangulation or measurement of atmospheric pressure. In the latter method the determinations are made either by means of the several forms of barometer or the hypsometer. The difficulties attending the use of all of the different forms of barometer were pointed out and the advantages of portability and accuracy of the hypsometer shown. Examples were then given illustrating the extremely satisfactory results obtained with the hypsometer during mountaineering expeditions in the Canadian Rockies last summer.

Professor Parker has had many years' experience in mountain work, making numerous "first ascents" in British Columbia and Alberta, and he gave as his conclusion that the hypsometer is by far the most convenient and accurate instrument for the determination of altitudes under ordinary mountaineering conditions.

Dr. **Kunz** in presenting the second paper stated that a naturally fractured piece of pitchblende (uraninite), weighing 800 grams, from Pribram, Bohemia, caused the $14\frac{11}{32}$ carat diamond (tiffanyite),[1] to phosphoresce when laid upon it, or even when a piece of window glass, or a board three fourths of an inch thick was interposed. The diamond glowed, although more than one inch of space intervened between it and the pitchblende. We have in this instance a substance with a radio-activity of only 2 or $2\frac{1}{2}$ affecting a radio-actively responsive substance, proving that there exists a body of the latter character in this case that responds almost to the unit one of radio-activity. The same specimen of pitchblende did not affect a platinum-barium cyanide screen. Another specimen of pitchblende from Pribram, and others from Johangeorgenstadt, Saxony, and

[1] *Science*, December 18, 1903.

Central City, Colorado, caused the diamonds to phosphoresce. It was further shown that if either kunzite (a variety of spodumene), pectolite or wollastonite, pulverized, were mixed with radium-barium carbonate, of 240 activity, the mixed powder became permanently luminous. When these mixtures were put in a Bologna flask and held on a metal plate, hot but not showing any color, they immediately became very luminous and remained so for a long time. Kunzite, pectolite and wollastonite became phosphorescent by heating alone, the kunzite showing an orange glow. When a kunzite crystal 5 cm. square and 5 cm. thick was exposed to the passage of an oscillating current, the entire crystal glowed an orange pink, losing its lilac color, a well-defined line through the center in the path of the current being much more brilliant; this phosphorescence lasted for quite a time after exposure. Further experiments were made with the same sensitive diamond mentioned above as to its tribo-luminescence. Prints were obtained from negatives made by laying the diamond face downward directly upon the photographic plate, and rubbing the back of the diamond with a stick coated with wool, in one instance for a quarter of a minute, in another for one half minute, the tribo-luminescence induced causing the printing. The same type of diamond from British Guiana, when heated on a metal plate below redness, phosphoresced distinctly, as also did pectolite and wollastonite. We have here, therefore, luminescence of the tiffanyite body in diamond, produced by radio-active pitchblende, by friction and by heat.

The paper by Dr. **Davis** was the first of a series of papers on "Recent Progress in Physical Science." Account was given of Dr. H. A. Wilson's investigation of the distribution of electrical intensity along the striated positive column, and his theory for the electrical intensity in a uniform positive column. An outline was also given of Professor J. J. Thompson's theory of the discharge through Geissler tubes. Dr. Davis also reviewed Professor J. S. Townsend's theory of the sparking potential, Professor Townsend having showed that the ionization is due to impact of both positive and negative ions with the neutral mole-

cule. The theoretical sparking potential thus deduced agrees very closely with the experimental value.

Charles C. Trowbridge,
Secretary.

SECTION OF BIOLOGY.

January 11, 1904.

Section met at 8.15 P. M., Vice-President Underwood presiding. The minutes of the last meeting of the Section were read and approved.

The following program was then offered:

Henry F. Osborn, The Classification of the Reptilia.

Adele M. Fielde, The Sense of Smell in Ants.

Summary of Papers.

Professor **Osborn** presented the history of the classification of Reptilia as follows: (1) Recognition of the Cotylosauria as the most primitive group of reptiles, by Cope and Baur. (2) The separation of the Anomodontia, Chelonia and Sauropterygia as reptiles with a single temporal arcade, by Smith Woodward and Broom. (3) The affiliation of the Ichthyosaur with the two-arched rather than the single-arched reptiles, by Baur and McGregor. (4). The recognition of *Sphenodon* as the ancestral type of the two-arched reptiles, by Baur and others. (5) Separation of the reptiles into two great groups of single-arched and two-arched types, by Smith Woodward and Broom. (6) The demonstration that reptiles are separated not only by the structure of the temporal arch but by many fundamental characters into two distinct groups, by Osborn and McGregor (1902). (7) Consequent division of the Reptilia into two subclasses Synapsida and Diapsida, by Osborn (1903). (8) The proposal of the Diaptosauria to include all of the most primitive two-arched reptiles without armature, by Osborn (1903). (9) The classification of the Reptilia according to the accompanying table (1903–4).

Class Reptilia.

I. Subclass Synapsida, Osborn.
  1. Order Cotylosauria, Cope [= Pareiasauria, Seeley].
    Family Diadectidæ.
    Family Pariotichidæ.
    Family Pareiasauridæ.
  2. Superorder Anomodontia, Owen [= Theromorpha, Cope, in part].
    Order I. Theriodontia, Owen.
      Suborder I. Therocephalia.
      Suborder II. Cynodontia, Owen.
    Order II. Dicynodontia, Owen. Inc. Sedis.
    Order III. Placodontia, Owen.
  3. Order Sauropterygia.
    Suborder I. Simosauria, Gervais [= Nothosauria].
    Suborder II. Plesiosauria.
  4. Order Testudinata.
    Suborder I. Pleurodira.
    Suborder II. Cryptodira.
    Suborder III. Trionychia.

II. Subclass Diapsida, Osborn.
  1. Superorder Diaptosauria, Osborn.
    Order I. Procolophonia, Seeley.
    Order II. Protorosauria, Seeley.
    Order III. Proganosauria, Baur.
    Order IV. Gnathodontia, Owen.
    Order V. Pelycosauria, Cope.
    Order VI. Choristodera, Cope.
    Order VII. Rhynchocephalia, Günther.
  2. Order Parasuchia, Huxley.
    Suborder I. Aëtosauria.
    Suborder II. Phytosauria.
  3. Order Ichthyosauria, Blainville, 1835 [= Ichthyopterygia, Owen, 1839]
  4. Order Crocodilia.
    Suborder I. Mesosuchia.
    Suborder II. Eusuchia.
    Suborder III. Thalattosuchia.
  5. Superorder Dinosauria, Owen.
    Order I. Theropoda, Marsh.
      Suborder I. Megalosauria [= Thecodontia, Owen].
      Suborder II. Compsognatha, Huxley.
    Order II. Opisthocœlia, Owen [= Sauropoda, Marsh].
    Order III. Ornithopoda, Cope [= Predentata, Marsh].
  6. Superorder Squamata.
    Order I. Lacertilia.
    Order II. Mosasauria.
    Order III. Ophidia.
  7. Order Pterosauria.

Miss **Fielde** described her experiments with many species of these insects. Each species appears to have its distinctive odor, discernible by other ants. Within each species there are also differences of odor, dependent on the age of the colony, and the age of the queen from whose eggs its inmates are produced. The ant's organs of smell are its antennæ, in which the joints are as a series of noses, each having a special function. The distal joint appreciates the nest-aura informing the ant whether it is in its own nest or in that of an enemy. The second joint discriminates between the odors of ants of the same species as itself, but of different colonies. The third joint discerns the scent of the track laid down by the ant's own feet, and enables the ant to return upon any route that has been previously traversed. The fourth and fifth joints smell the larvæ and pupæ, and the removal of these joints disables the ant from further care of the inert young. The sixth and seventh joints make known to the ant the presence of ants of other species than her own. So many as five joints may be retained by ants whose antennæ have normally eleven or twelve joints and these ants will live peacefully together though they be of different subfamilies. But if seven joints be retained, the ants, similarly grouped, will fight one another to the death. If ants make one another's acquaintance before they are twelve hours old they will thereafter live amicably together although they be of different species, genera or even of different subfamilies. But in three days after hatching their criterion of correct ant odor is established, and they refuse to affiliate with ants whose odor is not in accord with their standard.

M. A. Bigelow,
Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

JANUARY 18, 1904.

Section met at 8:15 P. M., Professor James F. Kemp presiding.

The minutes of the last meeting of the Section were read and approved.

In the absence of the Secretary, Dr. A. A. Julien was appointed Secretary *pro tem.*

The following program was then offered:

J. D. Irving, MICROSCOPIC STRUCTURE AND ORIGIN OF CERTAIN STYLOLITIC STRUCTURES IN LIMESTONE.

J. Howard Wilson, RECENT JOURNEYS AMONG LOCALITIES NOTED FOR THE DISCOVERY OF REMAINS OF PREHISTORIC MAN.

SUMMARY OF PAPERS.

From an extended examination of stylolitic limestones collected in Indiana and Wyoming, mainly by Mr. M. L. Fuller and himself, Dr. **Irving** has drawn the following conclusions regarding the origin of the peculiar structures:

1. They were initiated along a thin clay layer in limestone and have been produced by the interpenetration of the limestone material on either side of this clay seam.

2. They are entirely independent of the presence of fossils existing in the rock, for they occur equally in those portions of the rock where fossils are absent and where they are present.

3. They were not formed by metamorphic agencies, or by the weight of overlying strata, or by other causes which would tend to distort and crush the rock material.

4. They were produced by a cause which operated on the material of the rock while it was yet unconsolidated, and in a condition approximating that which obtained at the time of deposition.

5. They originated under great pressure, the rock material being sufficiently soft to allow the bending of individual stylolites, and yet potentially rigid so that organisms were sharply sheared off while held in the soft matrix.

While the cause of the pressure and the manner in which it had operated to produce these structures has not been determined, the author suggests that their production may be the result of the hydrostatic pressure of the sea water lying above the deposits. In the instances examined, stylolites are characteristic of marine deposits formed in water varying from 400 to 2,500 fathoms in depth. If sea water be taken to have an average specific gravity of 1.028, then a one-foot column of water exerts a hydraulic pressure of .434 lb. per sq. in. of area. This would give, for the depth stated, a hydrostatic pressure of from 1,041 to 6,408 lbs. per sq. in. Such a pressure as this, coupled with the soft unconsolidated nature of the rock at the time it might have been exerted, seems to fulfill better than any other the conditions demanded by the observed facts.

Mr. **Wilson** discussed Man in the earliest times before the Neolithic Age and afterwards illustrated his paper by nearly forty views of some of the most famoûs rock shelters, caves and deposits of Europe which have furnished remains of Palæolithic Man, including also slides of the type implements and weapons from which is derived the principal evidence of Man's existence in Quaternary times.

The paper recited briefly the history of the subject, the first finds, especially the work of Boucher de Perthes, and the gradual development of the science of prehistoric archæology. Reference was made to some of the disputed evidence of Man's existence in the Tertiary period, and then the subject of Man's undoubted existence as early as the Second Glacial period was treated more at length, with a consideration of the climate and physical conditions which prevailed in Palæolithic times.

The paper closed with an attempt at a realization of the great antiquity of Palæolithic Man as shown by the immense physical and geological changes which have taken place since he first made his undoubted appearance.

A. A. Julien,
Secretary pro tem.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

JANUARY 25, 1905.

The regular meeting of the section was held on January 25, at the American Museum of Natural History, in conjunction with the New York Branch of the American Psychological Association. Afternoon and evening sessions were held, the members dining together between sessions. The program was as follows:

Henry Rutgers Marshall, PRIMARY AND SECONDARY PRESENTATIONS.

Margaret E. Washburn, THE GENERIC RELATION OF ORGANIC SENSATION AND SIMPLE FEELING.

Francis Burke Brandt, THE UNIVERSE'S PLACE IN MAN.

Walter F. Dearborn, RETINAL LOCAL SIGNS.

Henry Davies, DEWEY'S "STUDIES IN LOGICAL THEORY."

Robert MacDougall, THE DISTRIBUTION OF ERRORS IN SPELLING ENGLISH WORDS.

Irving King, THE ULTIMATE RELATION BETWEEN MAGIC AND RELIGION.

SUMMARY OF PAPERS.

Dr. **Marshall** in his paper aimed to present evidence that presentations are always new presentations, and that, therefore, images can not be properly said to be copies of impressions, nor can what we call representations be properly said to be duplications of any presentations which have previously existed. His paper was a summary of an article which is presently to appear in *Mind*.

In his paper Dr. **Brandt** emphasized the necessity for a fresh start in modern empirical investigation through a critical restatement of the postulates of experience. The starting point of every empirical science, it was contended, is individual conscious experience. The primary datum of individual experience is a perceptive and a conceptive consciousness combined organically in the unity of a personal life existent in a universe of persons. The material universe thus primarily takes its place in man rather than man his place in the material universe, for scientific philos-

ophy has demonstrated beyond criticism, first, that the visible universe always exists primarily in and for a momentary perceptive consciousness limited in space, and second, that the unseen universe is always primarily a conceptive construction whose validity is always verifiable within the realm of momentary perceptive experience. The material universe, whether conceived phenomenally or existentially, participates in one case in the content, in the other in the being of absolute personality, and as such, so far as individual man is concerned, is the objectification of the conditions of higher individual development.

Mr. **Dearborn's** paper was offered as a critique of the first of the three Lotzean hypotheses concerning the nature of the retinal local signs. Experiments to determine the accuracy of the motor impulse, as shown by the ability to fixate directly eccentric visual stimuli forty degrees to the right of the primary line of regard, found an average error of corrective movements considerably in excess of the threshold value of local discrimination for the same part of the retina. These discrepancies between the accuracy of the motor impulse and the delicacy of local discrimination seem to necessitate some modification of the traditional view in regard to the nature of the local signs, or at least in regard to the relative importance of the motor factor.

In the paper by Dr. **Davies** only the four chapters contributed by Professor Dewey to the above work were considered.

Toward the right understanding of the work two conditions of a historical character must be borne in mind. One of these is the relation of recent logical theory to the Kantian dualism of sense and reason which tended to separate thought from its object. The other is the influence of the evolutionary method, which drives the investigator to study logical distinctions in the light of their genesis in experience.

Both of these conditions exert a profound influence over Dewey's thought. For it is the essence of his contribution to logical theory that he shows that the obstinate manner in which logicians have accepted the Kantian reading of experience is the most fruitful historical cause of the contradictions, *e. g.*, in Lotze's "Logic" as well as in that of Bradley and Bosanquet.

Dewey claims that this is a complete misreading of the thought situation.

On the other hand, common sense and empirical science with their pragmatic and evolutionary method disclose the real situation. Thought is a question of *specific* purposes, *specific* contexts and *specific* conflicts. Common sense and empirical science assume for these specific aims the unity and continuity of experience. The logical problem emerges when this is broken up by an inward conflict into fact and theory, datum and ideatum. The content of thought is just this conflict, which is only a temporary phase of the logical situation, the outcome of which must always be the reëstablishment of the original unity in our experience.

It follows from this that logic cannot contemplate as its aim a completely rationalized metaphysics. Rather its function is to act as a philosophy of experience, as a *method* by which experience may be advanced towards better and more complete knowledge. But the rectification of experience and the complete correlation of all the functions of experience presuppose a logic of genetic experience. It is Dewey's merit to have pointed this out and to have, in large part, supplied the need in the present work.

Dr. **MacDougall** made a provisional report upon an investigation of the distribution of errors in spelling English words. These occur characteristically in the latter part of the word, but do not present a continuous increase from beginning to end. The curve of error is an anticlinal having its maximum in the third quarter of the word and its points of origin the initial and final letters, of which the latter is the higher in the scale of errors. Similar relations are presented by the component syllables, fewest errors occur in the initial, most in the median letters. Considered apart from their relation to the termination of the word, the frequency of error in successive letters is found to increase with each remove from the beginning of the word.

Dr. **King's** paper stated that magic and religion can not be legitimately distinguished on the side of the actual content of their respective practices, nor by using such notions as that of

the supernatural, unless they are critically reconstructed with reference to the type of culture in which they are applied. It seems more legitimate to differentiate magic and religion according to the types of situations within which they appear. Some tensions in the experience of the primitive man are merely occasional and appeal to him chiefly as an individual; others are more general and appeal more insistently to the consciousness of the social group. In connection with the former sort of tensions magical practices are developed, and in connection with the latter variety religion differentiates.

James E. Lough,
Secretary.

BUSINESS MEETING.

February 1, 1904.

The Academy met at 8.15 P. M., Vice-President Poor presiding. The minutes of the preceding business meeting were read and approved.

The Secretary reported from the Council that a letter had been received from Mrs. H. Carrington Bolton, informing the Council that Dr. Bolton had given to the Academy, for the Publication Fund, the sum of $1,000.

The Academy then adjourned.

Henry E. Crampton,
Recording Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

FEBRUARY 1, 1904.

Section met at 8:20 P. M., Vice-President Poor presiding. The minutes of the last meeting of the Section were read and approved.

The following program was then offered:

D. S. Martin, H. CARRINGTON BOLTON.

Charles Lane Poor, RESEARCHES AS TO THE IDENTITY OF LEXELL'S LOST COMET OF 1770 WITH THE PERIODIC COMET OF 1889, 1896 AND 1903.

George B. Pegram, THE YEAR'S WORK WITH RADIUM.

SUMMARY OF PAPERS.

The biographical sketch of the late Dr. H. Carrington Bolton by Dr. **Martin** was read by Professor Crampton, the recording secretary of the Academy, in the absence of Dr. Martin. The section then passed a resolution, proposed by Mr. G. F. Kunz, to the effect that Dr. Martin's address should be published in the ANNALS of the Academy, together with a bibliography of Dr. Bolton's papers.

Professor **Poor's** paper gave the result of a new investigation of the motion of the periodic comet of 1889, 1896 and 1903 (Brooks), dealing especially with the great changes in its orbit caused by the close approach to Jupiter in 1886. The comet has now been seen at three returns to perihelion and the many observations made allow of a most accurate determination of the present orbit on which to base the investigation. Attention was called to the supposed identity of this body with the lost comet of Lexell, 1770, which disappeared after passing close to Jupiter in 1779, and this question was discussed at length.

Dr. **Pegram's** paper was the second of the series on "Recent Progress in Physical Science." Dr. Pegram gave a review of the most important experimental and theoretical advances made during the past year in the knowledge of radio-activity, especially the work of Rutherford and Soddy in formulating the atomic

disintegration theory of radio-active change, the discovery of Curie in regard to the heating effect of radium, and the experiments of Ramsay and Soddy bearing on the question of the continuous production of helium in radium compounds. An apparatus was exhibited like that of Mr. Strutt, to show by the alternate charging and discharging of an electroscope the production of electric charges by radium. The charging of the gold leaf in the apparatus shown by Dr. Pegram took place in about one minute.

Charles C. Trowbridge,
Secretary.

SECTION OF BIOLOGY.

February 8, 1904.

Section met at 8:15 P. M., Vice-President Underwood presiding. The minutes of the last meeting of the Section were read and approved.

The following program was then offered:

O. P. Hay, A New Gigantic Tortoise from the Miocene of Colorado.

F. E. Lloyd, The Flora of Dominica.

Summary of Papers.

Dr. **Hay** described a tortoise that was discovered during the year 1901 by Mr. Barnum Brown, of the American Museum of Natural History, in the Pawnee beds of the Miocene, in the northeastern part of Colorado. The remains consist of the shell complete; the skull, lacking the lower jaw; the pelvis and hind limbs; the terminal portion of the tail; and portions of the dermal armor. These materials were exhibited before the academy.

The length of the carapace is about 31 inches. It is high and tumid, with the sides at the bridge perpendicular, and with the hinder border little flaring. The outline is truncated in front, broadly rounded behind, and only slightly repand. The free edges are acute. The bridge peripherals rise somewhat above the middle of the height of the shell, their length transversely

to the animal being nearly equal to that of the costal plates. The nuchal scute is narrow; the vertebral scutes not so wide as the costal scutes. The anterior lip of the plastron is broad, rounded in front, and slightly notched in the midline. The posterior lobe has a broad, shallow notch. The pectoral scutes are extremely narrow.

The skull has the palate deeply excavated. The masticatory surface on each side is traversed by a prominent, sharp and dentated ridge. The oral surface of the premaxillaries is excavated for the reception of the tip of the lower jaw. The cutting border of the maxilla is coarsely dentated.

The exposed portions of the hinder limbs and probably of the fore limbs also, were protected by an armor of dermal bones, as in some living species of the genus. The extremity of the tail is expanded and covered on the upper surface by a plate composed of several bones joined by sutures. The skin of the region around the tail was provided with many pebble-like dermal bones. On the hinder part of each thigh there was a large bony spur. All these bones were covered in life with a thick layer of horn. This new species is named *Testudo osborniana*, in recognition of the interest of Professor H. F. Osborn in the fossil testudines.

Remarks were made by the author of the paper on the geographical and geological distribution of the genus *Testudo* and its related genera, and on their probable origin.

Professor **Lloyd** gave a general account of the vegetation of the Island of Dominica, which the author visited during last summer.

The Island is of volcanic origin, remarkably broken in contour, and very difficult for travel. The rainfall is excessive, but with considerable differences in distribution. For example, on the west coast there is a mean annual rainfall of 59.51 inches, while 239.50 inches were reported for Middleham in 1901, an amount not far from the mean. The eastern slopes of the island are exposed to the trade winds, and the vegetation, from the shore line to the top of the mountains, shows the effects in the peculiar moulding. The temperatures are not excessive, but the atmospheric humidity is great.

The vegetation, excepting in certain restricted areas, is of the tropical rain-forest type. The large trees are clothed with a heavy epiphytic growth chiefly composed of bromeliads, aroids, orchids, ferns and a *Cyclanthera*. At the higher levels the Hymenophyllaceæ, Musci and Hepaticæ predominate, among which, however, many larger ferns and small orchids find a place. Four species of tree ferns, and several species of palms are to be found. *Heliconia*, a plantain-like plant, is very abundant at high altitudes. Lianas and "ropes," as air roots are called locally, are abundant.

In the Grand Savannah, desert conditions prevail, caused by the small rainfall (59 inches), and the shallow soil underlaid by trap rock. The vegetation here, and along the rocky shores is quite distinct in character. A viviparous agave and four cacti are here to be found. The savannah is a sloping, grassy plain with scattered shrubs and small trees among which occur several Mimosoideæ.

The strand vegetation on account of the steep, gravelly character of the shore is meager in species. The sea-grape (*Coccolobis uvifera*) is everywhere, and *Ipomœa pes-capræ* and *Canavalia* are common. *Terminalia* occurs in some localities.

M. A. Bigelow,
Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

February 15, 1904.

Section met 8:15 P. M., Professor James F. Kemp presiding.

The minutes of the last meeting of Section were read and approved.

Twenty-six members and visitors were present.

The following program was then offered :

Alexis A. Julien, The Occlusion of Igneous Rock within Metamorphic Schists.

W. D. Matthew, Outlines of the Continents in Tertiary Times.

Summary of Papers.

Dr. **Julien** stated that the term "inclusive" is commonly applied, by the petrograper, to ordinary dikes of igneous rock, surrounded by beds of sedimentary rock or of crystalline schists, intersecting them or intervening between their foliation planes. But for similar masses cut loose from all connection with the underlying magmatic source, swallowed up within strata of crystalline schists, and experiencing all stages in the process of reaction and final absorption, during metamorphic change, another term seems to be called for, viz., "occlusion," signifying shut or sealed up beyond escape. Although the word is borrowed from the physicist, this can produce no confusion when applied to petrographic phenomena. Occluded igneous rocks may belong to either the acid or basic class, as illustrated respectively, on Manhattan Island, by the earlier intrusions of pegmatite, never found as intersecting dikes, and by the intercalated sheets of dionite-schist. Occlusion is usually attended by mechanical and chemical processes. The former consists of thinning or thickening of igneous masses caught between the folia of schists, during orogenic movements, into lenticular masses; the crumpling and corrugation of sheets, and even rolling into cylinders; and the forcing of the pasty masses along foliation planes, in the form of intercalated or "secondary" dikes. The chemical processes usually consist of micaceous alteration and ultimate absorption by disintegration and dissemination through the surrounding country rock.

In discussing this paper, Professor Kemp spoke of the value of the interpretation to those who have studied the region.

Dr. **Matthew** presented a series of world-maps showing the hypothetical outlines of the continents during the Pleistocene, Pliocene, Miocene, Oligocene, later Eocene, and at the opening of the Tertiary period, as contrasted with the modern conditions. The series was got up for use in the Hall of Fossil Mammals, in the American Museum of Natural History, to illustrate the geographical distribution of different groups of mammals during the successive epochs of the Tertiary and Quaternary. It is intended to represent a somewhat conservative view of past

changes in world geography, and is regarded as a working hypothesis, based on our present knowledge of geology, palæontology and zoölogy, especial consideration being given to the mammalian palæontology.

The former extension of the Antarctic continent, so as to join Australia with South America, is regarded as occurring at the end of the Cretaceous period and is represented in the first map of the series. The connection with South Africa is regarded as too problematic to place on the map. The Eocene map shows the extreme of Tertiary submergence of the continents, which are represented as forming six isolated land masses. The three northern continents are connected throughout the Oligocene, Miocene, Pliocene, and Pleistocene, Africa being joined to them by the Miocene, South America by the Pliocene epoch. The Pleistocene map shows especially the simultaneous glaciation of both northern and southern regions, modified in the north by sinking of the old Arctic continent beneath the sea-level.

The supposed ancient continents of Lemuria, Atlantis, the Brazil-African land bridge, etc., are regarded either as proposed on insufficient data or outside the limits of this series.

In general it has been found possible to consider the true ocean basins (limited by the 1,000-foot contour) as permanent through Tertiary time. The union of Antarctica with Australia and South America is an exception to this rule, but is based on a large amount of evidence. It appears probable also that the disturbed belt which stretches through central Europe to south-central Asia, and ends perhaps in the East Indian islands, has been, in part, raised from abyssal depths to an equally stupendous height above the sea, since the beginning of the Tertiary.

Discussion. — Professor Osborn emphasized the value of these maps as expressing working hypotheses for the use of students of vertebrate palæontology.

Dr. Julien called attention to the evidences of glaciation in South Africa as having a bearing upon the question of a previous existence of land masses further south.

Edmund Otis Hovey,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

February 29, 1904.

The regular meeting of the section was held on February 29, at the American Museum of Natural History, in connection with the American Ethnological Society.

The program was as follows:

George H. Pepper, Ethnological Survey of the Pueblos of New Mexico and Arizona, During the Summer of 1903.

Harlan I. Smith, Archeological Survey of the Interior of the State of Washington During the Summer of 1903.

Summary of Papers.

Mr. **Pepper** first went to Española and from there visited the pueblos of Santa Clara, San Ildefonso, Pojoaque, Nambe and Tesuque. One of the ceremonial dances at the pueblo of Santa Clara was witnessed. San Juan, Picoris and Tesuque next received attention. After this work was completed the Hopi region was visited, the time selected being the occasion of the Antelope and Snake dances at Walpi. In the pueblos of Hano, Sichomavi and Walpi, special attention was devoted to the work of the Hopi potters, particularly Nampayo of Hano, who is the only one living that has made a careful study of the old pigments and clays.

On the second mesa the pueblos of Mashongnavi and Shungopavi were visited, and the Snake Dance at Mashongnavi observed. Oraibi, the seventh of the Hopi pueblos, situated fifteen miles to the west of the second mesa, came next. During the stay in this pueblo the wonderful Flute ceremony was enacted. From the Hopi region the route taken led to the pueblo of Laguna in the western part of New Mexico, and from there to Acoma, where the Fiesta de San Esteban was seen. While in the pueblo of Isleta the Fiesta de San Augustine took place.

Visits to the pueblos of Jemez, Zia, Santa Ana, Ranchitas de Santa Ana, Sandia, San Felipe, Santo Domingo, Cochiti and Zuñi completed the season's work, which included all of the twenty-six "mother pueblos," now inhabited.

The subject of primitive pottery-making as represented in the various groups was carefully considered and the technique of each culture was investigated. Samples of the materials used in the manufacture of pottery were obtained as well as representative forms of finished vessels from each pottery-making pueblo. Nearly one thousand negatives were made to supplement the field notes, and to enhance the value of the exhaustive card catalogue pertaining to southwestern ceramics, which is now in the course of preparation.

Mr. **Smith** stated that archeological explorations of the Jesup North Pacific Expedition were carried on in 1897 by himself in the Thompson and Fraser River valleys of Southern British Columbia, and 1898–99 in the shell-heaps along the coasts of British Columbia and Washington. In continuance of the general archeological reconnoissance thus begun in the northwest, the Columbia valley was chosen as the field for research during the field season of 1903.

It was thought that by working in the Yakima Valley the boundary between the culture of The Dalles and that of the Thompson River region might be determined. The material, however, discovered by the expedition seems to prove that the Yakima Valley was inhabited by people having a culture which previously had been unknown to science.

In the region were found numerous evidences of the close communication of the people of this culture with tribes of the Thompson River region. Underground house sites, tubular pipes, engraved detalium shells, a decoration consisting of a circle with a dot in it, and rock-slide sepulchres, each of a particular kind, were found to be peculiar to both regions.

Considerable material of the same art, as that found in the Dalles region was seen. It is clear that the people living in the Yakima valley had extensive dealings both with the tribes northward, as far as the Thompson valley, and southward, as far as The Dalles of the Columbia. In this connection it is interesting to note that the present Indians of the region travel even more extensively than would be necessary to distribute their artifacts this far. Much less evidence of contact between

the prehistoric people of the coast of Washington and that of the Yakima valley was discovered. A pipe, however, was seen which is clearly of the art of the northwest coast. It was found far up the Toppenish River (one of the western tributaries of the Yakima).

From the Yakima valley the expedition was transferred to the lower Cowlitz River for work down that stream and along the Columbia from Portland to its mouth, partly to determine whether or not a portion of the evidences of coast culture which were found in the Yakima valley had not come up the Cowlitz and down the Toppenish River, since the headwaters of the Cowlitz and the Toppenish are near each other. In this region many specimens were secured. The main work, however, was done in the Yakima valley, where many photographs were taken, not only of archeological sites but also of the country in general. Human remains, which are useful in determining the type of these old people, were also collected.

The most remarkable specimen secured was a piece of antler carved in human form. This was very thin and when found it was nearly as soft as so much sawdust or moulder's sand pressed together tightly. Proper treatment has rendered the object quite hard and able to bear handling. It was found under the vertebræ of a child in a grave. The grave was of peculiar interest, because, contrary to usual practice, the body had been enclosed in a rude box made by placing about it thin slabs of stone, and the cist thus formed had been covered with jagged fragments of rock, over which earth was spread. This doll-like carving of antler is considered to be one of the finest pieces of prehistoric art ever found in northwestern America.

James E. Lough,
Secretary.

BUSINESS MEETING.

MARCH 7, 1904.

The Academy met at 8:15 P. M., Vice-President Poor presiding.

In the absence of the Recording Secretary, the reading of the minutes of the preceding Business Meeting was dispensed with.

No business was reported from the Council, and the Academy adjourned.

C. C. TROWBRIDGE,
Secretary, pro tem.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

MARCH 7, 1904.

Section met at 8:20 P. M., Vice-President Poor presiding.

The minutes of the last meeting of the Section were read and approved.

The following program was then offered:

S. A. Mitchell, THE RESULTS OF THE OBSERVATIONS OF THE LAST SOLAR ECLIPSE.

Dr. Mitchell gave an interesting résumé of the results obtained by the different expeditions which made observations in the island of Sumatra on May 18, 1901.

CHARLES C. TROWBRIDGE,
Secretary.

SECTION OF BIOLOGY.

March 14, 1904.

Section met at 8:15 P. M., Professor Underwood presiding.

The minutes of the last meeting of the Section were read and approved.

The following program was then offered:

A. W. Grabau, Intra-Colonial Acceleration and Retardation in Development.

F. B. Sumner and **R. C. Osburn,** The Establishment of a Permanent Record of Systematic and Ecological Data for Woods Hole.

No abstracts of these papers have been received.

M. A. Bigelow,
Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

March, 21, 1904.

Section met at 8:15 P. M., Professor James F. Kemp presiding.

The minutes of the last meeting of the Section were read and approved. Twenty-two members and visitors were present.

The following program was then offered:

H. H. Wotherspoon, Jr., The Recent Advances in the Utilization of Peat and Lignite.

Charles P. Berkey, A Geological Reconnoissance of the Uintah Reservation, Southeastern Utah.

Summary of Papers.

Mr. **Wotherspoon** showed that the derivation of the fuel supply of the word is becoming more and more important. For years Europeans have been striving to devise a fuel to take the place of wood and coal. Recent advances in the price of coal in the United States have directed attention in this country along the same lines. In Europe and particularly

in Germany, many factories have been established for the compression of lignite, or brown coal, and peat into briquettes.

The principal deposits of lignite are near Berlin and Cologne. The larger of these is south and east of Berlin and is known as the Lausitz district. About 280 factories for the manufacture of briquetted fuel, with a total of 680 presses, have been established in these two regions, and their output in 1902 was approximately 12,438,000 metric tons. The briquettes are about 7 inches long, 2½ inches wide, and 1½ inches thick, with rounded corners. Their wholesale price in the larger German cities is between $2.10 and $2.25 per metric ton.

Excellent briquettes have been made from the lignite of Alabama ; but the experiments with the lignites of North Dakota have been less successful. The calorific value of the German briquettes is from 7,500 to 9,000 B.T.U.'s. True peat and other bog matter is becoming of importance in the manufacture of briquetted fuel. The process of manufacture which has been employed in Canada has depended upon heat for the expulsion of the major part of the contained moisture. This has been an unsatisfactory method, because the temperature (280° F.) necessarily employed has weakened the natural cementing qualities of the bog material.

The German method which has been very successful is to break up rapidly and thoroughly the cellular structure of the partly decomposed vegetable matter. This sets free the water from the plant fiber without injuring the cementing material. In the process, part of the moisture is squeezed out of the mass, and the remainder evaporates rapidly on exposure to the air. The briquettes are ready to use in about two weeks after leaving the machine. Their calorific value is greater than that of the briquettes made from lignite.

The briquettes made from American bog matter seem to be as good as the European. The percentage of ash is high, but the ash is very free in character. This characteristic together with the absence of sulphur, makes the fuel work well under boilers. Wherever transportation charges bring the cost of

coal up to seven or eight dollars a ton, it is advisable for Americans to investigate the matter of utilizing neighboring bogs as a source of fuel supply. Mr. Wotherspoon's paper was illustrated by a series of briquettes manufactured from European and American lignites and peats. He also exhibited a machine by means of which he manufactured, in the presence of the Section, briquettes from peat, which originated in Danbury, Conn. The paper was actively discussed, and many questions bearing upon the economic features brought forward by the author, were asked.

Dr. **Berkey** spoke of his observations, made in connection with other lines of work last summer, that have shown an erosion unconformity in the Carboniferous strata of the western Uintahs. It is marked on the south side of the range by an unevenness in the floor and a development of conglomerate, the pebbles of which are of the preceding formation. The break comes just above the chief limestone member of the series.

The junction between the great basal quartzite of the United States and the overlying strata is marked by a fault in this region with sufficient throw to bring two quartzite beds together on the higher plateaus and be easily overlooked. This makes it impossible to confirm Powell's unconformity at the top of the quartzite as described by him in the eastern Uintahs.

The discovery, however, of the Carboniferous erosion interval a little higher in the series, throws additional doubt upon the assumed Carboniferous age of the great quartzite member. Allowing the break to cut out a part of the "Wasatch" limestone and the "Weber" quartzite, as developed in the Wasatch uplift, the lithologic succession is satisfied better by assuming Cambrian age for the lowest member in the Uintahs.

There is no other break to the close of the Cretaceous. A progressive unconformity, which increases in value against the flanks of the range, marks the development of Tertiary sediments in the Duchesne Valley. A conglomerate, formed in progressive overlap from the stream valleys to the higher mountain tops of the flanks, has peculiar characters near the limestone belt on account of which King called it "Wyoming"

conglomerate. These characters are too local to give it the assumed stratigraphic importance, while the flanking conglomerates are really of great range. EDMUND OTIS HOVEY,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

MARCH 28, 1904.

Section met at 4:30 and 8:15 P. M., in conjunction with the New York Branch of the American Psychological Association, F. J. E. Woodbridge, presiding.

The afternoon session was held at the Psychological Laboratory of Columbia University, and the evening session at the American Museum of Natural History.

The following program was offered:

E. L. Thorndike, MENTAL RESEMBLANCES OF TWINS.

Miss **Naomi Norseworthy,** MEASUREMENTS OF THE MENTALLY DEFICIENT.

R. S. Woodworth, COLOR CONTRASTS.

J. McK. Cattell, NEW APPARATUS AND METHODS.

V. A. C. Henmon, THE TIME PERCEPTION AS A MEASURE OF DIFFERENCES IN SENSATION.

H. H. Marsh, THE DAILY CURVE FOR EFFICIENCY.

C. H. Judd, HABITS BASED ON ANALOGY.

W. P. Montague, A NEGLECTED POINT IN HUME'S PHILOSOPHY.

J. E. Lough, THE DETERMINATION OF THE HABIT CURVE FOR ASSOCIATIONS.

P. Hughes, ACTION AS THE CONCEPT OF HISTORICAL SYNTHESIS.

SUMMARY OF PAPERS.

A report was made by Professor **Thorndike** on the general results of a comparison of twins in tests of attention, perception, association, rate of movement, addition, multiplication and stature. The resemblances as measured by a rough, preliminary method, were about .75. The amount of this resemblance that should be attributed to similarities in home training was apparently slight. There was no evidence in the results to support the theory that

twins fall sharply into two species, those very closely alike and those no more alike than ordinary brothers and sisters.

Miss **Norseworthy's** paper was a report of some work done among one hundred and fifty mentally deficient children in two state institutions for the feeble-minded and in two of the special classes organized in the New York schools. The measurements taken were physical, such as height, height and temperature, tests of maturity, as perception of weight and of form, tests of memory and tests of intelligence or the ability to deal with abstract ideas. The main conclusion reached was that the difference between idiots and people in general is less than has been commonly supposed, and is a matter of degree rather than of kind.

Dr. **Woodworth** presented a modification of Hering's binocular demonstration of the "physiological" origin of simultaneous contrast. If monocular fields of different colors, with a gray spot on each, be combined by the stereoscope, each gray retains the contrast color suitable to its own field, however the conscious background may vary as the result of fusion or rivalry of the two fields. The demonstration is readily extended to cover brightness contrast, by placing gray spots on white and black fields which are combined as before. To show that these effects are not the result of a binocular mixture of the gray with the opposite field, a number of gray spots may be scattered over one field, and the other field made particolored; the gray spots appear all alike, or nearly so, though binocular mixture would have made them differ.

Professor **Cattell** gave an exhibition of some new apparatus and methods as follows:

1. Kymographs were exhibited in which typewriting ribbons were applied to secure the records. Electro-magnetically moved points strike the paper tape, whose rate of movement may be adjusted, and a record is left by the slowly moving typewriter ribbon. Two forms were exhibited, in one of which the kymograph was driven by an electric motor and in the other by clock-work. In the latter the clock-work could be started and stopped by an electric current by an observer in another room. The kymographs, while not especially suited for drawing curves, are much

more convenient than smoked paper or siphon pens for time records, such as rhythms, conflict of the visual fields, after-images, etc.

2. Instruments were shown by which a number of faint clicks could be given at intervals of a second for testing sharpness of hearing and defective hearing. Instead of giving the observer a continuous sound, such as from the ticking of a watch, two, three, four or five faint sounds are made, and the observer is asked how many he hears. By this method errors from the common illusion in the case of faint sounds are avoided.

3. A method was exhibited for testing color blindness by the time it takes to distinguish one color from another. By the normal individual red can be distinguished from green in about the same time as blue from yellow, but it takes longer to distinguish red from orange. If the observer belongs to the red-green class of the color blind, he can distinguish blue from yellow as quickly as others, but not red from green. An instrument was shown by which the conditions of the railway service can be imitated, it here being necessary first to distinguish a certain color and then to make the proper movement.

The aim of the investigation upon which Mr. **Henmon's** paper is based is to measure qualitative differences in color by the time of perception. The colors taken as standards were red, orange and yellow, whose wave-lengths had been definitely determined. Equal intermediate steps between orange and red were produced by the mixture of pigments. Small squares of each of these colors, 3 x 3 cm., were mounted on cards side by side with red, and exposed to the subject by means of a drop-screen so arranged as to give almost instantaneous exposure. The subject reacts with the right or left hand according as the predetermined stimulus appears to the right or left. The registration is made with the Hipp chronoscope. The results of 6,000 reactions gave evidence of the validity of the method and the fruitfulness of the problem. Equal objective differences are correlated with differences for consciousness, showing a definite increase as the magnitude of difference is decreased.

Professor **Lough** presented a report of experiments made in the psychological laboratory of the school of pedagogy. It was found that the time required to write series of letter-equivalents when the "key" of equivalents was not memorized, but was consulted as frequently as necessary, diminished as the associations between the letter equivalents became more habitual. The curves representing the results of these experiments exhibit all the characteristics of the typical habit curve. Repetition of the experiment using new "keys" shows little or no interference due to earlier associations, while with each succeeding "key" the physiological limit was reached after a constantly diminishing number of trials.

The paper by Dr. **Montague** aimed to show (1) that Hume (in Part IV, Section II, of the "Treatise") had quite unwittingly furnished what from his own point of view should have been regarded as a logical deduction and justification — rather than the mere psychogenetic description, which it purported to be,— of the realistic belief in the independent and uninterrupted existence of sensible objects; and (2) that the *naïve realism* or positivism thus accidentally promulgated was from both the scientific and the popular standpoint, a far sounder and more inviting doctrine than the empirical idealism or sensationalism with which Hume's name is usually associated.

Mr. **Hughes** said that Rickert's description of the content of history as a reality is amended to read *past reality*, the past of evidence. From this definition the individual, objective, moving and continuous character of historic content follows; and further, the conception of action as descriptive of both historic content and historic synthesis. An historical synthesis is a past action that itself has created a certain synthesis of evidence, which the historian discovers. In such synthetic actions, "simple" actions retain their individuality as means, stimuli or hindrances to the main action, *i. e.*, in a functional relation.

At the close of the afternoon session the members were invited to attend a lecture given in Columbia University by Professor John Dewey on "The Psychologist's Account of Knowledge."

James E. Lough,
Secretary.

BUSINESS MEETING.

April 4, 1904.

The Academy met at 8:20 P. M., Vice-President Poor presiding.

The minutes of the preceding business meeting were read and approved.

The following candidates for election as Active Members, approved by the Council, were duly elected:

Thomas Hunt Morgan.

Charles B. Davenport.

The Academy then adjourned.

Henry E. Crampton,
Recording Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

April 4, 1904.

Section met at 8:20 P. M., Vice-President Poor presiding. The minutes of the last meeting of the Section were read and approved.

The following program was then offered:

J. K. Rees, Harold Jacoby and **Herman S. Davis,** The Variation of Latitude at New York City; Part 2, Variation of Latitude and Constant of Aberration.

George B. Pegram and **Harold Webb,** Energy Liberated by Thorium.

Wallace Goold Levison, Note on a Tribophosphoroscope, and the Duration Spectrum of Tribophosphorescent Light.

Summary of Papers.

In the first paper Professor **Jacoby** presented the results of seven years' continuous observations for a study of latitude variation and the aberration of light, which results will be published as the second and last part of Vol. I, in the Academy's

Series of Memoirs. To that publication the reader is referred for complete details and results; it is not possible here to do more than mention very briefly the plan of the work and to state the fact of its completion.

The simultaneous and continuous observation of the same stars at stations situated on a single parallel of latitude, but separated widely in longitude, has long been recognized as the best method of attacking the problem under consideration. The first actual practical application of the method is the one treated in the present paper. The other participating observatory is the one at Capodimonte, near Naples, where simultaneous observations were made by Professor Fergola and his associates.

The New York and Naples work was continued until a similar, but a more elaborate, plan was put in operation by the International Geodetic Association, which includes all civilized governments. This plan involved the establishment of four suitable special latitude stations, and rendered further work at New York and Naples unnecessary.

The method used by Messrs. **Pegram** and **Webb**, in this investigation of the energy liberated by thorium due to its radioactivity, was to measure the difference between the temperature of three kilograms of thorium oxide, enclosed in a Dewar bulb, and that of a surrounding ice-bath, by means of a set of iron-constantin thermo-electric couples. Uniformity of temperature in the bath was secured by means of a rotating stirrer and careful heat insulation. The thorium oxide was cooled, so that its initial temperature was below that of the surrounding bath. Readings were taken at frequent intervals, and after several days the difference of temperature became constant, with the oxide $.04^\circ$ warmer than the bath. Several such series of observations were made. From the rate of change of temperature and from an approximate calculation of the heat capacity of bulb and oxide, a tentative value of the heat liberated was found; 8×10^{-5} gram-calories per gram of thorium oxide per hour (.93 ergs per gram per second), or 9×10^{-5} gram-calories per gram of pure thorium per hour. Further investigation is being made to determine these values more accurately.

Mr. **Levison** presented the following note on a Tribophosphoroscope:

Discs of thick pasteboard about 15 cm. in diameter are evenly sanded on one or both sides on a coating of liquid glue with the materials to be examined in powder, narrow bands being sufficient and only small quantities of the materials required.

The disc selected is then rotated at a known and usually moderate speed (twelve revolutions per second, for example) by any convenient mechanism, such as an ordinary rotator used for illustrating the recomposition of light.

A point or brush of wire or other material, or a piece of the same material with which the disc is coated, being pressed against the sanded surface, produces a trail of light which extends from the point of contact in an arc more or less around the disc; varying in color with different materials and in length with the speed, and is maintained for some time unless the material is rubbed off by extreme friction. A grindstone or corundum wheel may often be used to advantage with hard substances as a substitute for the disc, since a specimen held against it soon coats it with a trace of the material which shows its luminous trail beautifully.

By means of the device described, the intensity of the light may be determined with a photometer, its duration from the length of the trail, and its spectrum delineated with a spectroscope.

The following approximate tentative results of the examination of a few minerals are given to illustrate its applicability.

1. Sphalerite (1) from Utah. Light yellow concretions in gray massive sphalerite. Visible trails of a yellow orange color of respectively increasing brilliancy and length are produced with the tip of the finger; a wooden match; the finger nail; a brass wire brush; and a steel wire brush, or point; visible, with the latter, at a distance of several yards and extending about one quarter around the disc at the above speed. Hence, the duration is about 0.02 s. The spectrum is short, extending from about the line *C* to the line *E* and embracing some red, orange, yellow, yellow-green and green. (2) From another

locality very similar to the above in character, and afforded like results. (3) Of several dark colored sphalerites some showed a little light at the point of contact of the brush, but no trail.

2. Quartz. (Sandpaper disc or grindstone.) No light from brushes (except incandescent sparks from hard steel). A piece of quartz, however, gives a bright yellow light, and if of rock crystal is luminous within by internal reflection. Very short trail and duration.

3. Corundum. (Emery paper disc or corundum wheel.) No light from brushes (except as above). A piece of ruby or ruby corundum against the corundum wheel or a grindstone evokes a brilliant crimson light and short trail and is luminous within by internal reflection. Duration about 0.005 s. A piece of emery against a corundum wheel gives a like trail but is not itself luminous.

4. Pectolite, Woodcliff, N. J. Wire brush. Light greenish-blue trail only medium bright but extending completely around the disc. Duration over 0.08 s.

5. Limestone, Hellfire Rock, Utah. Feeble greenish-blue but similarly long trail. Duration over 0.08 s.

6. Willemite. (1) Hard yellow-green gem material, Franklin, N. J. Short greenish-yellow trail. Duration very short. (2) Opaque, massive green variety. Feeble short green trail. Duration about 0.02 s. Best obtained with a specimen pressed against a corundum wheel or grindstone. Various specimens give somewhat different effects. (3) Pink or brown variety. Longer and brighter green trail. Duration about 0.03 s.

7. Chlorophane. (1) Violet from Trumbull, Conn. Bright green and very long trail; best obtained by friction of a specimen against a grindstone or corundum wheel or a disc coated with the same material. Duration over 0.40 s. Spectrum broad band in the yellow-green and green. (2) Green from Amelia Co. Courthouse, Va. Trail similar but brighter; spectrum similar. (3) Red from Haddam Neck, Conn. Trail similar.

In the discussions that followed the papers, Dr. George F. Kunz stated that Professor Baskerville and himself had under

examination a zinc-blende from Utah, the natural mineral varying in color from yellow to fawn and to pale brown. This was the most intense tribo-luminescent substance that they had yet investigated. Two bits one fourth the size of a pea, if pressed together lightly with the fingers, caused a brilliant yellow-green light to glow as long as the pressure lasted; and it also possessed the property of becoming radio-responsive to the beta and gamma rays of radium; that it was the first natural zinc-blende they had examined that showed this remarkable property.

Mr. W. J. Hammer showed a sample of artificial blende made by Mr. W. S. Andrews, of Schenectady, N. Y., which gave very strong tribo-luminescence.

C. C. Trowbridge,
Secretary.

SECTION OF BIOLOGY.

April 11, 1904.

Section met at 8:15 P. M., Professor Underwood presiding.

The minutes of the last meeting of the Section were read and approved.

The following program was then offered:

Gary N. Calkins, The Evidence of a Sexual Cycle in Amœba Proteus.

E. B. Wilson, The Cleavage-Mosaic in Patella.

D. T. MacDougal, The Ecological Conditions in a Local Desert in Lower California.

Summary of Papers.

Professor **Calkins** presented "The Evidence of a Sexual Cycle in *Amœba Proteus*" as shown by nuclear changes, including the processes of mitosis and nuclear multiplication by this method, the fragmentation of the multiple nuclei, the mitotic division of the chromatin fragments, and the formation of the secondary nuclei, and subsequent encystment of the parent form. The entire process was regarded by the speaker as indicating a series of changes leading up to the formation of

conjugating gametes and exactly analogous to the formation of gametes in allied rhizopods such as *Polystomella*, *Centropyxis*, and *Chlamydophrys* as recently worked out by Schaudinn. Lantern slides were used for illustrations.

Professor **Wilson'** ssubject was "The Cleavage-Mosaic in *Patella* ; with remarks on the Mosaic-Theory of Development." This paper will soon be published in full in the *Journal of Experimental Zoology*.

Professor **MacDougal** gave a short talk on the topography, water-fall, drainage, botanical and zoological conditions in a local desert in Lower California.

GARY N. CALKINS,
Acting Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

APRIL 18, 1904.

Section met at 8:15 P. M., Professor James F. Kemp, presiding.

The minutes of the last meeting of the Section were read and approved.

The following program was then offered :

Arthur Hollick, A CANOE TRIP DOWN THE YUKON RIVER FROM DAWSON TO ANVIK.

Edmund Otis Hovey, THE GRAND SOUFRIÈRE OF GUADALOUPE, AN ANALOGUE OF MONT PELÉ.

SUMMARY OF PAPERS.

Dr. **Hollick** said in brief: The trip was made under instructions from the United States Geological Survey, with the special object of collecting palæobotanical material, from which to determine the age of certain exposures in central Alaska.

The party consisted of Dr. Hollick, Mr. Sidney Paige, field assistant, and Mr. John Rentfro, cook and general camp assistant. The start was made from Seattle, Wash., on June 1, 1903, by steamer to Skagway, Alaska, where they arrived on

June 5, and remained until June 11, waiting for the ice to break up in the Yukon River. On June 11, the route was by railroad to Whitehorse, Yukon Territory; June 12–15, by steamboat down the upper waters of the Yukon to Dawson, Yukon Territory, where a nineteen-foot Peterboro' canoe was purchased and the trip down the river begun. The trip was ended at Anvik, Alaska, August 12, after about 1,100 miles of the river had been explored, and about 1,800 lbs. of specimens had been collected and shipped. The highest point north was reached at Fort Yukon, July 2, just beyond the Arctic Circle.

The Yukon River occupies what was until quite recently a broad estuary. Subsequent elevation of the land resulted in the draining of the estuary and the formation of the present river valley, which has cut its way down through the estuary deposits, leaving these as broad benches or terraces. Mastodon and other remains of extinct animals indicate the Pleistocene age of the deposits. One of the finest exposures is at the "Palisades," just below Rampart.

The width of the river varies from one to ten miles, and the main channel is constantly shifting. It pursues a meandering course, sometimes impigning on the side of the old valley, sometimes on the other, and for long distances flows through the middle. Where it occupies the latter position, it is generally broad, with a current of about four miles per hour, and filled with innumerable wooded islands, mud flats and sand and gravel bars, which render navigation more or less a matter of guesswork, on account of the impossibility of telling where the main channel flows, and the liability of running into a blind slue or a long circuitous channel around an island. It was often found advisable to climb up the river bank to a considerable elevation in order to determine, by means of an extended view, where the correct course lay. Where hard rocks were exposed along the river banks, or a short distance away, these were subjected to careful examination in regard to their lithologic, palæontologic and stratigraphic characters.

Amongst the interesting results obtained were (1) the determination of the Tertiary age of certain sandstones above Ram-

part; and (2) the determination of the Cretaceous age of other sandstones and shales further down the river in the vicinity of Nulato. At one locality, a unique fossil flora was found, totally different from any heretofore known in America, consisting of Cycads of Lower Cretaceous types, mixed with Angiosperms belonging to what have always been considered Upper Cretaceous types.

Only a preliminary study has been made of the material collected, which will eventually be carefully examined and reported upon for the United States Geological Survey.

The paper was illustrated with about seventy lantern slides, showing the principal topographic and geologic features of the route.

Dr. **Hovey** showed twelve lantern slides illustrating the Grand Soufrière of Guadeloupe, and stated that the field evidence indicated that the present active cone of this volcano was closely analogous to the new cone and spine of Mont Pelé, Martinique; that is to say that it had been pushed up bodily into its present position, or had welled up through the conduit in such a viscous condition that contact with the atmosphere rendered it too rigid to flow. At the base of the cone, on the north, there is a gently rising flat area, apparently the segment of a circle, indicating the position of a part of the rim of a crater in existence before the construction of the present cone.

The map shown in connection with the paper was prepared by M. Léon Le Boucher for the Club des Montagnards of Guadeloupe. This Club has recently celebrated the first anniversary of its founding, and its report shows that it has done a great deal in a short time toward the opening up of roads and paths to the Soufrière, making the highest and one of the most interesting mountains of the Lesser Antilles readily accessible to visitors.

Sixty members and visitors were present at the meeting of the Section.

EDMUND OTIS HOVEY,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

April 25, 1904.

Section met at 8:15 P. M., Professor F. J. E. Woodbridge, presiding. The minutes of the last meeting of the Section were read and approved.

The following program was then offered:

William Jones, Notes on an Algonkin Dialect.

Franz Boas and **Clark Wissler**, On the Growth of Children.

Marshall H. Saville, Paper-making Implements of Ancient Mexico.

Waldemar Jochelson, The Grammar of the Yukaghir Language.

Summary of Papers.

Dr. **Jones** presented a brief report of the method of word formation of the Fox dialect. The dialect is Algonkin and belongs to the group now inhabiting, or that once inhabited, the country contiguous to Lake Huron, Lake Michigan and Lake Superior. Among the other dialects of the group are Ojibway, Ottawa, Pottowatomie, Menomonie, Kickapoo, and Sauk. Morphologically all these dialects stand in an intimate relation to one another. The absolute forms of much of the vocabulary are the same, but varying differences in the way of intonation, articulation and grammar, make some of these dialects seem somewhat removed from one another. Fox is near to Sauk and Kickapoo, and farther removed from Ojibway.

The structural peculiarities of word building, as shown in the Fox, would come out much the same in the other related dialects. The system of forming words is by composition. The elements entering into composition are formatives and stems. Some formatives are prefixes but most are suffixes. Some of the suffixes refer to the pronoun and gender in the same form. Stems fall into two general classes, initial and secondary. Initial stems come first in a combination and secondary stems come after. Secondary stems can be subdivided into at least two

groups, one of the first order and another of the second: the former stand next to initial stems, and the latter, when in composition, stand next to terminal pronouns.

The stems refer to general notions. Initial stems usually express subjective states and secondary stems generally refer to objective relations. The meaning of one stem modifies the meaning of another in a reciprocal manner, with a result of greater specialization. Initial stems have greater extension and can often occur alone as adverbs.

A number of particles precede the terminal pronouns. The particles refer to causal relations. Some have the special office of instrumentality, as with the hand, foot, mouth, voice and ear.

The dialect makes a distinction between two opposing categories. Objects that have life and movement come in one class, and objects without those attributes fall in another. The distinction is maintained with great vigor throughout the dialect. A force like personification sometimes interferes with it.

Professor **Boas** and Dr. **Wissler** presented a joint paper, in which they discussed the causes of the increased variability during the period of growth. On the basis of the results of previous investigations, it had been suggested that the increased variability may be due to differences in the rapidity of development. The authors have followed out this line of investigation by collecting material regarding the variability of the period at which certain physiological changes take place. The times of dentition, the beginning of puberty, the appearance of the wisdom teeth, and the beginning of senility, were selected for this purpose, and it was shown that the variability of time at which these phenomena take place increases with increasing age, and apparently the rate of increase is proportional to the age. Furthermore it was shown that during the period of growth all the coefficients of correlation between the sizes of different parts of the body are increased. This can also be best explained by the theory that the phenomena of growth are largely due to acceleration and retardation. The paper by Professor Saville was illustrated by specimens.

The paper by Mr. **Jochelson** reported the results of several

years' study of the Yukaghir language, being mainly a sketch of the Lolyma dialect. The phonetic and morphological peculiarities of the former are rather insignificant, but the Tundra dialect has absorbed a considerable number of Tungus stems, which in their use in word-formation have been subjected to the rules of the Yukaghir grammar. These investigations show that the Yukaghir language stands isolated from the Siberian languages of the so-called Ural-Altaic group, and that it has many similarities to the languages of the American Indians.

The chief phonetic and morphological differences that distinguish the Yukaghir languages from the Ural-Altaic languages are the following: 1. It has not the intricate system of vowel harmony that is found in Ural-Altaic languages. 2. We do not find that the vowel of the root is unchangeable — an important rule in Ural-Altaic phonetics. 3. The Ural-Altaic possessive suffixes of nouns and verbs are wholly absent in Yukaghir verbs, and present in nouns only for the purpose of expressing ownership of the third person. 4. Words are formed by means of suffixes and prefixes, while the Ural-Altaic languages use suffixes only.

The chief points of similarity between the Yukaghir language and Indian languages are: 1. The existence of a simple harmonic law in the use of vowels. 2. The use of prefixes. 3. Adjectives are morphologically identical with verbal forms. 4. The verb-bases are mostly stems, consisting of a single vowel or a small group of consonants, while the noun bases are almost always derivatives of verbal-forms. 5. The conjugation of transitive verbs is clearly distinguished from that of intransitive verbs. 6. Transitive verbs may be changed into intransitive verbs by means of suffixes, and vice versa. 7. We find in the Yukaghir language the polysynthesis of the American languages. 8. Although there is not the actual incorporation of the American languages, the syntactical construction of the Yukaghir sentence is akin to it.

James E. Lough,
Secretary.

BUSINESS MEETING.

May 2, 1904.

The Academy met at 8:15 P. M., Vice-President Poor presiding.

The minutes of the preceding business meeting were read and approved.

The following candidate for election as an Active Member, recommended by the Council, was duly elected:

William L. Osgood Field.

The following Active Members recommended for election as Fellows, were duly elected:

Professor Thomas Hunt Morgan.

Professor Charles B. Davenport.

The Secretary reported from the Council as follows:

That the Council had voted to return to the former method of publishing, three or more parts to be issued annually.

That a special committee appointed to consider the best method of combining the libraries of the Academy and of the American Museum, has reported as follows:

"1. That the Library Committee be authorized, in coöperation with the American Museum of Natural History, to set aside and dispose of such volumes in the library of the Academy as may not in their judgment be needed for the proper utilization of the two libraries; provided, that the proceeds derived from the sale of such volumes be devoted to the purchase of additional books and that books so purchased shall be a part of the Academy library.

"2. That the Library Committee be authorized in coöperation with the American Museum of Natural History to revise the exchange list of the Academy in such a way as to avoid such duplication of exchanges by the two institutions as may in their judgment seem undesirable."

It was voted that the recommendations of the Council be approved.

The Academy then adjourned.

Henry E. Crampton,
Recording Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

May 2, 1904.

Section met at 8.25 P. M., Vice-President Poor presiding. The minutes of the last meeting of Section were read and approved.

The following program was then offered:

R. S. Woodward, The Theory of a Double Suspension Pendulum.

C. C. Trowbridge, Measurements of the Primary Feathers of recently killed Hawks, and their Bearings upon the Problem of Bird Flight.

George B. Pegram, The Generation of Electrical Charges by Radium.

P. H. Dudley, Bending Moments in Rails, for the same Superstructure, under Different Types of Locomotives.

Summary of Papers.

Professor **Woodward** described a double suspension pendulum apparatus for determining the acceleration of gravity and gave a brief outline of the theory of the apparatus. The latter consists of two rectangular bars of brass, about twenty kilograms mass each, connected by two steel tapes of equal length in such a way that when one bar is held rigidly horizontal, the other bar will be suspended horizontally by the equal and parallel tapes. It was shown that when the suspended bar vibrates longitudinally through small amplitudes its motion is very nearly the same as that of a simple pendulum whose length is equal to that of the tapes. It was shown also how small corrections due to the mass of the tapes and to their rigidity may be applied in order to get from the actual apparatus results in conformity with those of a simple pendulum.

Dr. **Trowbridge** stated that during the spring he had succeeded in obtaining a series of measurements of the primary feathers of the hawk's wings, immediately after the death of the birds, and secured additional proof of his theory that certain

birds of prey habitually interlock their primary feathers in flight.

It was found that when hawks are examined immediately after they have been killed, there usually appear deep depressions in the edge of the posterior webs of the emarginate primary feathers, where the feathers have been in contact, which are caused by the interlocking of the primaries.

The measurements consisted in determining the width of these depressions at short intervals of time immediately after the death of the hawks. It was found that the depressions gradually disappeared, both in cases where the feathers were found locked and were then unlocked, and in cases where the feathers were found unlocked. Data were thus obtained from which well-defined curves were constructed, showing the recovery of the web of the feathers after the pressure caused by the interlocking feathers was relieved. A number of life-size photographs were taken of the primary feathers immediately after the hawks were killed and the photographs of the depressions in the feathers when measured by a Repsold measuring machine, gave curves which agreed very well with those obtained by direct measurement. Similar curves were obtained by artificially interlocking the primaries for several hours and then measuring the recovery of the web of the feathers with a micrometer microscope. It was found that artificial locking of the feathers for ten minutes produced very slight or no depressions and locking them for several hours produced depressions only about one half as deep as those found when the hawks were killed. In the latter case they were from 2 to 3.5 millimeters deep, and required from one to five hours to be reduced to twenty per cent. of the original depth, the rate of change of the depth of depression being most rapid at first.

It was concluded from the measurements and photographs that the primary feathers found with the depressions in the web had been interlocked several hours or more, previous to the death of the hawks, which were killed while sailing in a strong wind, and that the theory of interlocking of the primaries of the wing in flight had been conclusively confirmed.

Dr. **Pegram's** paper related to the generation of electrical charges by radium, with special reference to the suggestion of Soddy that when the α particles, carrying their positive charge, are expelled from the radium, there is no corresponding negative charge left behind in the mass. A few milligrams of radium bromide were enclosed in a thick lead capsule, which was supported on a quartz rod in an exhausted vessel. Gold leaves attached to this capsule gave no indication of a charge, showing either that there was the usual generation of equal amounts of positive and negative electricity when the α particles are thrown off, if, as has been supposed, the number of α particles is much greater than the number of negatively charged particles, or else that the number of β particles is about equal to the number of α particles. It remains to try a similar experiment with radium bromide which has been recently in solution, and, therefore, sends off few of the β particles.

Dr. **Dudley** referred to his previous communications to the Academy, describing the stremmatograph tests, which afforded tabulations of the recorded unit fiber stresses in the base of rails, and their distribution under moving locomotives and cars.

The determination from the unit fiber strains, of the negative and positive bending moments of the rails, due to the passing wheel effects, indicates that for a definite construction of the superstructure of the permanent way, they are independent, partially, of the total load of the locomotive or car, but dependent upon the type of each, in construction of wheel base and wheel spacing, in loading the foundation.

In a series of stremmatograph tests, on the New York Central and Hudson River Railroad, near mile post No. 10, December 23 and 30, 1899, locomotive No. 870, an eight-wheel type of engine, weight, 220,000 pounds, drawing the "Empire State Express" of four cars, weight, 430,000 pounds, at speeds of 42 and 44 miles per hour, the average positive bending moments for the engine were 12.40 inch-pounds per pound of static load, for one rail, constrained by a negative bending moment of 1.88 inch-pounds.

The average positive bending moments for the entire loco-

motive were 11.48 inch-pounds, per pound of static load, constrained by a negative bending moment of 1.71 inch-pounds.

On December 30 locomotive No. 2032, a ten-wheel type of engine, with closer wheel spacing, weighing 283,900 pounds, drawing the "Southwestern Limited" of ten cars weighing 910,000 pounds, at a speed of 40 miles per hour, at the same place as the preceding tests, the positive bending moment for the engine was 10.80 inch-pounds per pound of static load, for one rail, constrained by a negative bending moment of 2.18 inch-pounds — a more favorable result than for the eight-wheel type.

For the entire locomotive, the positive bending moment — for normal tender wheels — was 9.82 inch-pounds, for one rail, constrained by a negative bending moment of 1.90 inch-pounds, indicating a more favorable loading of the foundation. The bending moments of different types of locomotives on the same superstructure are a measure of the relative efficiency of the distribution of their loads to the foundation; while with the same type of engine the relative efficiency of the construction of the superstructure of the permanent way can be measured. These are first bending moments measured in rails under moving locomotives and cars.

Dr. H. G. Piffard exhibited an electrometer specially designed for use in measuring radioactivity, and showed the action of the instrument by lantern projection.

C. C. Trowbridge,
Secretary.

SECTION OF BIOLOGY.

May 9, 1904.

Section met at 8:15 P. M., Vice-President Underwood presiding. The minutes of the last meeting of Section were read and approved.

The following program was then offered:

E. W. Berry, The Cycadofilicales and the Origin of the Seed Plants.

D. T. MacDougal, Morphogenic Changes Caused by the Transposition of Aquatic and Terrestrial Plants.

After the stated papers were presented Professor Dean exhib-

ited and read an interesting letter signed by Lamarck in 1796, at the Museum of Natural History in Paris. Professor Lloyd described a species of violet with a tendency to form three spurs of equal radial symmetry. Dr. MacDougal described the primrose plants, illustrating the mutation theory of de Vries, which are now growing at the New York Botanical Garden.

MAURICE A. BIGELOW,
Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

MAY 16, 1904.

Section met at 8:15 P. M., Professor James F. Kemp presiding. The minutes of the last meeting of the Section were read and approved.

On motion, duly seconded, it was voted that the Academy apply for registration in the Eighth International Geographic Congress to be held in Washington, New York, etc., in September, 1904, and that the Chairman appoint the allowed number of delegates, himself to be one of the number. The Chairman appointed Professor J. J. Stevenson and Dr. E. O. Hovey to serve with him as delegates, three appearing to be the number allowed to the membership of the Academy.

In the absence of Mr. J. W. Gidley, who was to have read a paper entitled "Some Observations on the So-called Tertiary Lake Basins of Western North America," the program of the evening was necessarily changed from that which had been given in the printed announcement.

The following program was offered :

W. D. Mathew, EXHIBITION OF A SERIES OF FOOT-BONES ILLUSTRATING THE EVOLUTION OF THE CAMEL, RECENTLY INSTALLED IN THE HALL OF VERTEBRATE PALÆONTOLOGY OF THE AMERICAN MUSEUM OF NATURAL HISTORY.

E. O. Hovey, SOME EROSION PHENOMENA IN ST. VINCENT AND MARTINIQUE.

J. Howard Wilson, SOME OF THE LOCALITIES IN FRANCE AND ENGLAND WHERE MONUMENTS OF THE LATE STONE AND BRONZE AGES HAVE BEEN FOUND.

Summary of Papers.

Dr. **Mathew** described a series corresponding to that illustrating the evolution of the horse, and which is almost equally complete.

It shows the derivation of the camel from small primitive four-toed ancestors which were exclusively North American in habitat. The earliest known ancestors are tiny animals no larger than a rabbit. The camels reached their maximum size and abundance in the Pliocene epoch, when they were much larger than the modern camels. Then they spread to the other continents, disappeared entirely from North America and became smaller in size and far less numerous in species elsewhere.

Dr. **Hovey** showed lantern slides from some of the photographs taken by him in St. Vincent and Martinique in 1902 and 1903, for the American Museum of Natural History, which illustrated the development of the new drainage systems and the reinstatement of old channels in regions which were most thickly covered by the 1902 and 1903 eruptions of the Soufrière and Mont Pelé.

In considering the subject of stone monuments, Mr. **Wilson** confined himself to those found in Northern France and Southern England, and especially to the great groups near Carnac in Morbihau, and the well-known temples of Stonehenge and Avebury, in Wiltshire.

The monuments were divided according to type into several classes, and a description of each of these given briefly with their comparative ages and the probable purposes for which they were constructed. Legends concerning these monuments were cited, and mention was made of the superstition and veneration with which they have been regarded by some of the more conservative peasants, causing the worship of stone to be kept up to the present day in some remote districts.

Before closing the paper, attention was called to the engineering skill required in placing and erecting some of the monuments and the early age at which it made its appearance. The paper was followed by slides showing photographic views of

some of the most famous monuments, with maps and with drawings of several of the curiously engraved stones.

EDMUND OTIS HOVEY,
Secretary.

BUSINESS MEETING.

OCTOBER 3, 1904.

The Academy met at 8:15, Vice-President Poor presiding.

The minutes of the preceding business meeting were read and approved.

There being no business to come before the meeting, the Academy adjourned.

HENRY E. CRAMPTON,
Recording Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

OCTOBER 3, 1904.

Section met at 8:25 P. M., Vice-President Poor presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered:

Reports of summer work were presented by several members of the Section, after which an informal address was given by Dr. C. D. Perrine of the Lick Observatory, on "Recent Progress made in the Study of Nebulæ by Photographic Methods."

CHARLES C. TROWBRIDGE,
Secretary.

SECTION OF BIOLOGY.

OCTOBER 10, 1904.

Section met at 8:15 P. M., Professor F. B. Sumner presiding.

The minutes of the last meeting of Section were read and approved.

The meeting was devoted to reports on summer work by members. Professor E. B. Wilson worked at the Naples, Sorbonne and Roscoff laboratories, continuing his studies of ger-

minal localization in mollusks. Professor Bashford Dean attended the zoölogical congress at Berne and the British Association meeting in Cambridge, and later visited places of scientific interest in France. Professor Bristol worked at the Bermuda Biological Station, of which he was one of the directors. Mr. Yatsu worked at the Tufts College laboratory in Maine. Mr. Kellicott worked at the Cedar Point laboratory, in Ohio, completing his studies of the development of the vascular system of *Ceratodus.* Dr. Dublin continued his studies of germ cells at the Cold Springs Harbor laboratory. Dr. Townsend superintended the remodeling of the water-supply apparatus at the New York Aquarium. Mr. Bigelow conducted special courses for teachers in the summer-school of Columbia University. Professor Sumner directed the laboratories and the biological surveys of the Bureau of Fisheries at Woods Hole.

M. A. Bigelow,
Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

October 17, 1904.

Section met at 8:15 P. M., Professor James F. Kemp presiding.

The minutes of the last meeting of the Section were read and approved. The following program was then offered:

The special business of the evening was the nomination by the Section of officers to serve for the calendar year 1905. The following officers were unanimously nominated by the Section:

For Chairman and Vice-President of the Academy, E. O. Hovey, of the American Museum of Natural History.

For Secretary, A. W. Grabau, of Columbia University.

The program of the evening was then taken up. It was as follows:

E. O. Hovey, St. Vincent, British West Indies. The Eruptions of 1902 and Their Immediate Results.

Summary of Papers.

Dr. Hovey gave a summary account of the results obtained on two expeditions undertaken by him for the American Museum of Natural History in 1902 and 1903, for the study of the volcanic eruptions of the Soufrière, which began in May, 1902. Particular attention was devoted to the heavy coating of volcanic ash deposited upon the northern portion of the island of St. Vincent and the ash-filling of the gorges of the Wallibou and Rabaka Dry Rivers, the devastation wrought in the forests and on the plantations within a radius of about five miles from the crater, the phenomena of primary eruptions observed in the crater and of secondary eruptions observed in the Wallibou and Rabaka ash-beds. The nature of the exploding eruption cloud was discussed, and it was shown how the heavily dust-laden steam cloud kept close to the surface of the ground under the influence of gravity, while its initial velocity was furnished by the horizontal component of the explosion.

About eighty lantern slides were used in illustrating the speaker's remarks.

E. O. Hovey,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

October 24, 1904.

The Section met, in conjunction with the New York Branch of the American Psychological Association, at 4:30 P. M., and at 8:15 P. M. Vice-President Woodbridge presided.

The following program was offered:

R. S. Woodworth, The Correlation between Motor Strength, Quickness and Accuracy.

Robert MacDougall, Organic Levels in the Development of the Nervous System.

Irving King, Some Problems of the Fringe of Consciousness.

E. L. Thorndike, A Comparison of the Mental and Physcal Resemblances of Twins.

F. J. E. Woodbridge, Note on the Nature of Consciousness.

Proceeding to the election of officers for the coming year, the following were elected:

Chairman — Professor F. J. E. Woodbridge.

Secretary — Dr. R. S. Woodworth.

R. S. Woodworth,
Secretary, pro tem.

BUSINESS MEETING.

November 7, 1904.

The Academy met in Fayerweather Hall, Columbia University, at 8:30 P. M., Vice-President Poor presiding.

The minutes of the preceding business meeting were read and approved.

The following candidates, approved by the Council were duly elected as Active Members:

Fred. A. Lucas,

C. William Beebe.

There being no further business to come before the meeting, the Academy adjourned.

C. C. Trowbridge,
Secretary, pro tem.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

November 7, 1904.

Section met at 8:25 P. M., Vice-President Poor presiding. The minutes of the last meeting of Section were read and approved. The names of candidates for active membership were read and referred to the Council according to the By-Laws.

The following program was then offered:

F. L. Tufts, The Relation of Kathode Resistance to the So-called Saturation Current in the Discharge through Gases.

C. C. Trowbridge, The Duration of the Afterglow Accompanying the Electrodeless Discharge at Low Pressure.

The regular annual election of officers of the section was then held, which resulted as follows:

Chairman — Ernest von Nardroff.

Secretary — C. C. Trowbridge.

Summary of Papers.

Mr. **Tufts** pointed out that the so-called saturation currents, obtained by Wilson and other investigators of the phenomena of electrical conduction through flame gases, were not true saturation currents, but only apparently so, owing to the development at the kathode of a high resistance, when the impressed electromotive forces were over a few volts. By the use of a kathode coated with calcium oxide and heated by a separate flame, it was shown that the resistance of a flame connecting this with the flame remained practically constant. In other words, the current through the connecting flame increased directly as the potential gradient for gradients ranging from a few tenths of a volt to the centimeter up to gradients of as much as fifty volts to the centimeter. It was stated that experiments had been tried with the ordinary luminous gas flame as well as with flames rendered nonluminous by the admixture of air, and the relation between current and potential gradient was found to be the same for both kinds of flames. It was stated that experiments were in progress in which higher gradients than fifty volts to the centimeter were to be used.

Dr. **Trowbridge** stated that the purpose of the investigation was to determine the nature of the glow that often appears after the cessation of the electrodeless discharge in gases at low pressures. Measurements made thus far on the duration of the glow in air, show a sharp maximum of duration between .1 and .05 millimeter pressures and that this maximum point varies with the electrical conditions of the experiment. It was also determined that there is a critical point between .7 to .3 millimeter pressures where the glow is only occasionally formed,

after which, as the pressure is further reduced the duration of the glow increases rapidly to the maximum. The electrodeless discharge was also made to take place at liquid air temperature, and it was found that the afterglow accompanying the discharge, while still fairly strong, was diminished considerably in duration and intensity at the low temperature of about — 186° C.

The meeting then adjourned.

C. C. Trowbridge,
Secretary.

SECTION OF BIOLOGY.

November 14, 1904.

Section met at 8:15, Professor Underwood presiding.

The minutes of the last meeting were read and approved.

The following program was then offered:

W. E. Kellicott, Development of the Venous System of Ceratodus.

M. A. Bigelow, Some Pressure-Experiments on the Eggs of the Crustacean Hippolyte.

Summary of Papers.

F. E. Lloyd, Botanical Research at the Desert Laboratory in Arizona.

Dr. **Kellicott's** paper, on the "Development of the Venous System of *Ceratodus*," pointed out many similarities to the amphibian. These similarities are so numerous and exact, that it seems impossible to believe that the Dipnoi and Amphibia have not arisen as a common stock which has separated later into these groups. The adult relations and the mode of development of the vena cava of *Ceratodus* indicate that this vessel is not to be looked upon as one of the hepatic veins which has made a new connection with the posterior cardinal vein, but that its anterior portion develops as a short cut by way of which the blood from the mesonephros may be carried to

the heart after the atrophy of the pronephros and the associated veins.

Mr. **Bigelow** briefly described some observations on eggs of the crustacean *Hippolyte* subjected to slight pressure during cleavage. While the normal cleavage is total, pressure prohibited the formation of cell-boundaries, and unsegmented eggs with 2, 4, 8, 16 and 32 nuclei were obtained. When the pressure was removed the cell-boundaries soon appeared. The cleavage of this egg under pressure exhibits some striking resemblances to the normal superficial cleavage of eggs of allies.

Professor **Lloyd** described the conditions for botanical research at the Desert Botanical Laboratory in Arizona. Many photographs were exhibited to illustrate descriptions of the peculiar flora in the vicinity of the laboratory and of the method of conducting experiments, especially those concerned with the relation of desert plants to water.

Dr. W. M. Wheeler, of the American Museum of Natural History, was elected chairman, and M. A. Bigelow, of Teachers College, Columbia University, secretary of the section for the year 1905.

M. A. Bigelow,
Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

November 21, 1904.

Section met at 8:15 P. M., Professor James F. Kemp presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered:

Summary of Papers.

John J. Stevenson, The Island of Spitzbergen and Its Coal.

James F. Kemp, The Titaniferous Magnetite in Wyoming.

In introducing his subject Professor **Stevenson**, described briefly the coast of northern Norway and its geology and referred in some detail to Bergen, Hammerfest and other cities. Spitzbergen was then taken up and its coals and their geological relations were passed in review. The coal beds are of Jurassic age and the coal is peculiar in that it partakes of the characters of the lignites as well as of the true coals.

The second paper on the program, by Professor **Kemp**, was presented only in abstract. The magnetite occurs in two places, fifteen and twenty miles north of Laramie, Wyoming, the former and smaller occurrence being near the Shanton ranch, the latter and larger being on Chugwater Creek. Both are in wall rock of anorthosite which is practically indistinguishable from anorthosite occurring in the Adirondacks. The ores range from 20 per cent. to 40 per cent. TiO_3. Thin sections show that they contain green spinels, and one slide presents much olivine. They can be most reasonably explained as intrusive dikes. In this view the speaker agreed with Waldemar Lindgren who has published a brief note regarding them.

The Section then adjourned.

James F. Kemp,
Secretary, pro tem.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

November 28, 1904.

Section met at 8:15 P. M., F. J. E. Woodbridge presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered :

A. M. Tozzer, Survivals of Ancient Rites Among the Lacandone and Maya.

Clark Wissler, Ceremonial Life of the Blackfoot.

Summary of Papers.

Mr. **Tozzer** held that the unity of origin of the Lacandones of Chiapas and the early inhabitants of Yucatan seems established by the fact of the many relevant survivals of rites and

customs connected with the older culture as described by the early inhabitants and missionaries, as, for example, the cosmical conceptions, the use of incense-burners identical with some found in the ruins of Yucatan, the piercing of the ear with a stone knife, and the worship of jade and other idols of stone, long identical with Magle culture. That the Lacandones are the descendants of a lower stratum in the social organization of the Magas, the "gens rustica," seems evident from the lack of anything approaching skill either from an architectural or an artistic standpoint, the probable absence of a priestly class and along with this a seemingly complete ignorance of the ancient system of writing used among the Magas.

Dr. **Wissler** discussed the general results of research in the religious life and practices of American Plains Indians, showing that the idea that supernatural power was received by the individual in a vision, dream or inspiration, led to the conception of an individual right to the use of such power, and that even in religious rites recognized as tribal, the formal ownership was vested in a single individual, and that the power of such rites in the affairs of men could work through his consent alone. It further appears that the right of the owner to transfer the religious rite was recognized and that this had a commercial aspect. This reached such a complex stage of development that it practically determined the whole economic organization of the people. On the subjective side, it appears that the real power sought and operated through the songs making up the ritualistic rites and that material objects and dance evolutions were regarded as secondary. The songs were regarded as prayers that the supernatural giver would always heed.

R. S. Woodworth,
Secretary, pro tem.

SECTION OF GEOLOGY AND MINERALOGY.

December 2, 1904.

Section met at 8:25 P. M., Vice-President Kemp presiding.

The minutes of the last meeting of the Section were read and approved.

The Section held a special meeting, at which 200 members and visitors were in attendance. The meeting was called to order at 8:25 P. M., and the programme of the evening was at once taken up. This consisted of a lecture by Professor Albrecht Penck, of the Imperial University at Vienna, who is an Honorary Member of the Academy.

The speaker discussed "The Glacial Surface Features of the Alps," and gave a brief summary of some of the results of the twenty years of masterly work which has been done by him and under his direction in the Tyrol. Professor Penck discussed in popular language the nature of the valleys of the Alps and showed by means of lantern slides and a diagram how the glaciers have widened and deepened portions of their rocky basins and produced lakes.

After a vote of thanks to the distinguished guest of the evening, the Section adjourned.

Edmund O. Hovey,
Secretary.

BUSINESS MEETING.

December 5, 1904.

The Academy met at 8:30 P. M., Professor William Hallock presiding.

The minutes of the previous business meeting were read and approved.

The Secretary reported from the Council as follows:

That it was proposed to amend Chapter V, Section 1, of the By-Laws, by omitting the words "Every Active Member shall pay an initiation fee of $5, within three months of his election or such election shall be void."

That the Council, as required by the By-Laws, had prepared the following nominations for officers for the coming year:

President — James F. Kemp.

Vice-Presidents — Edmund O. Hovey, Ernest R. von Nardroff, F. J. E. Woodbridge, William M. Wheeler.

Corresponding Secretary — Richard E. Dodge.

Recording Secretary — Henry E. Crampton.

Treasurer — Charles F. Cox.

Librarian — Ralph W. Tower.

Editor — Charles L. Poor.

Councilors — Emerson McMillin and F. H. Wiggin.

The following candidates for election as Honorary Members had been approved by the Council:

Hugo de Vries.

G. Johnstone-Stoney.

W. C. Brogger.

Karl von der Steinen.

Ferdinand Zirkel.

That the Annual Meeting would consist of a formal session for the presentation of the reports of officers and election of officers for 1905, and that this would be followed by a subscription dinner, at which the address of the President would be delivered. Due notice would be given the members regarding time and place of this meeting.

The Academy then adjourned.

Henry E. Crampton,
Recording Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

December 5, 1904.

Section met at 8:30 P. M., Professor William Hallock presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered:

C. W. Kanolt, The Combination of Ions with the Solvent in Solutions.

Bergen Davis and **C. W. Edwards,** Chemical Combination of Knall-gas under the Action of Radium.

SUMMARY OF PAPERS.

The object of Dr. **Kanolt's** investigation was to determine whether or not the ions of a salt in solution are combined with the solvent. The method used was the electrolysis of a salt dissolved in a mixture of two solvents, with the subsequent analysis of the portions of the solution around the two electrodes. If the ions are combined with either of the solvents, this solvent will be carried from one electrode to the other, and changes in the proportions of the two solvents are to be expected. Positive results were obtained with silver nitrate dissolved in a mixture of pyridine and water, indicating that pyridine was combined with silver ions. With the same salt in a mixture of alcohol and water, only negative results have so far been obtained. Other salts are being investigated.

The experiments of Professors **Davis** and **Edwards** relate to the chemical combination of hydrogen and oxygen under the action of radium rays. The gases were enclosed in a vessel in such a way that a small change of pressure could be observed. About four milligrams of radium bromide were dissolved in alcohol and deposited on the surface of a small sheet of platinum which was placed in the vessel.

By means of electrodes the amount of ionization produced in the gas by the radium was measured. While the rate of formation of water was quite slow; yet the number of molecules of water formed for each physical ion produced, was very large. The experiments are being continued by Professor Edwards.

C. C. TROWBRIDGE,
Secretary.

SECTION OF BIOLOGY.

DECEMBER 12, 1904.

Section met at 8:15 P. M., Vice-President Underwood presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered:

Henry F. Osborn, RECENT DISCOVERIES OF EXTINCT ANI-

MALS IN THE ROCKY MOUNTAINS AND THEIR BEARINGS ON THE PRESENT PROBLEMS OF EVOLUTION.

F. B. Sumner, EXPERIMENTAL STUDIES OF ADAPTATION AND SELECTIVE ELIMINATION IN FISHES.

SUMMARY OF PAPERS.

Professor **Osborn** exhibited the newly prepared skulls of *Diplodocus, Morosaurus* and *Creosaurus* from the Bone Cabin Quarry, Wyoming. The skull of *Morosaurus* is new to science, and is of a short-skulled type with a very prominent and convex forehead. Like *Diplodocus* it exhibits a large pineal foramen.

Under the title "Recent Discoveries of Extinct Animals in the Rocky Mountain Region and their Bearings on the Present Problems of Evolution," Professor Osborn exhibited a series of skulls of the Eocene ancestors of the Oligocene Titanotheres, stating as a result of recent investigation that the Oligocene Titanotheres were found to represent four distinct lines of descent, in each of which horns independently developed, and that the Eocene Titanotheres also represented four distinct lines of descent, two of which became extinct, namely, the extremely short-skulled *Palæosyops*, and the extremely long-skulled *Dolichorhinus*, while the intermediate forms *Telmatotherium* and *Manteoceras* gave rise to the Oligocene forms *Titanotherium* and *Megacerops* respectively. As bearing upon the general problem of evolution, it was pointed out that the palæontologist enjoys the peculiar advantage of following a series through the origin and development of organs to their subseqent progression or decline. As early as 1888 the speaker had taken the ground that various palæontological series demonstrate the *definite or determinate variations* of certain kinds. In 1892 he connected with this the idea that certain series of animals related by descent from a common stem form exhibit the *potential of similar evolution*, describing this as a law of latent or potential homology. It is now found in this series of Titanotheres that there is more than a potential of similar evolution; there is evidence of a *predisposition to similar evolution* as shown in the wholly independent development in two distinct series of horns from hornless types

at exactly similar points on the skull, namely, at the lateral junction of the frontals with the nasals.

The communication had been in part presented before the Brooklyn Institute of Arts and Sciences, and before the Zoölogical Congress at Berne.

Dr. **Sumner** described his experiments that were undertaken in order (1) to determine the relative sensitiveness to asphyxiation of the three commoner species of *Fundulus*; (2) to determine the relative ability of these and some other fishes to survive transfer to fresh water; (3) to determine the minimum salinity which certain salt-water fishes could withstand; (4) to determine the effect upon these fishes of gradual and of abrupt changes in the density of the water.

The results of extended biometric studies were set forth, from which (1) it was shown that when a given species was subjected to destructive conditions, and the mean characters of the more and the less resisting individuals were compared, differences were evident both in respect to type and to variability; (2) that when different methods of elimination were employed with the same species, selection had reference to different characters; (3) in the only case in which this question was tested, that the selective elimination of two closely related species, under the same conditions, appeared to have reference to the same characters; (4) that specimens of *F. heteroclitus* inhabiting brackish water of low salinity differed in all of the measured characters from those living in pure salt water. (5) It was shown, nevertheless, by comparison with the more and the less fit individuals of those experiments where fresh water was employed as the eliminative agent, that the fishes inhabiting brackish water could not have owed their modification to the natural selection of those individuals better adapted to a life in water of a lower density. (6) It was shown by comparing the mean characters of the three species of *Fundulus* and by taking into account their relative fitness to withstand certain conditions, that these differences of type could not have been due to natural selection acting with reference to these particular conditions.

Dr. Hornaday, director of the New York Zoölogical Park, and

Dr. Townsend, director of the New York Aquarium, called attention to some of the animals recently added to the collections in their charge.

MAURICE A. BIGELOW,
Secretary.

ANNUAL MEETING.

DECEMBER 19, 1904.

The annual meeting of the New York Academy of Sciences was held on December 19, at the Hotel Endicott, at 7:30 P. M. Professor Edmund B. Wilson presided. A formal session was first held, for the transaction of the regular business of the Academy, and this was followed by a dinner at which sixty-six members and their friends were present.

The appended reports of the Corresponding Secretary, Recording Secretary, Treasurer, Librarian and Editor were presented, and by vote placed on file. The report of the Treasurer was formally referred to the Finance Committee for audit.

The Academy then proceeded to elect officers for the year 1905, tellers being appointed, official ballots prepared by the Council according to the provisions of the by-laws, being distributed, and the votes counted. The following officers were declared elected:

President — James F. Kemp.

Vice-Presidents: Section of Geology and Mineralogy, Edmund O. Hovey.

Section of Astronomy, Physics and Chemistry, Ernest R. von Nardroff.

Section of Biology, W. M. Wheeler.

Section of Anthropology and Psychology, F. J. E. Woodbridge.

Corresponding Secretary — Richard E. Dodge.

Recording Secretary — Hermon C. Bumpus.

Treasurer — Charles F. Cox.

Librarian — Ralph W. Tower.

Editor — Chas. Lane Poor.

Councilors (to serve three years) — Emerson McMillin, F. H. Wiggin.

Finance Committee—John H. Hinton, C. A. Post, Henry F. Osborn.

Proceeding to the election of Honorary Members, the following eminent men of science were formally presented, each by a Fellow of the Academy engaged in scientific work of the same nature as that of the nominee, and were duly elected:

Hugo de Vries, presented by N. L. Britton.

G. Johnstone-Stoney, presented by R. E. Dodge.

W. C. Brögger, presented by J. F. Kemp.

Karl von der Steinen, presented by Franz Boas.

Ferdinand Zirkel, presented by J. J. Stevenson.

Dr. Frederick A. Lucas was elected a Fellow of the Academy, being presented by the Recording Secretary.

Professor Cattell then proposed the health of Professor R. S. Woodward, a past-president of the Academy, recently elected to the presidency of the Carnegie Institution.

The President, Professor Edmund B. Wilson, then delivered his address upon "The Problem of Development," at the close of which a vote of thanks, proposed by Professor H. F. Osborn, and seconded by Professor J. J. Stevenson, was tendered to him.

The Academy then adjourned.

Henry E. Crampton,
Recording Secretary.

REPORT OF THE CORRESPONDING SECRETARY.

December 19, 1904.

The Corresponding Secretary makes the following report as to the status of the Honorary and Corresponding Members.

A little over a year ago letters were sent to all the Honorary and Corresponding Members on the lists of the Academy. As a result from the returns of these letters the lists have been greatly improved in accuracy and completeness.

At present there are forty-five honorary members. One honorary member, Professor Von Zittel, has died since the last annual meeting.

The list of Corresponding Members numbers one hundred

and eighty-three, of whom one hundred and forty-four have answered the communication sent a year ago. There are, therefore, thirty-nine who have not been heard from. Another letter of inquiry will be sent out in the spring and a failure on the part of these thirty-nine to answer this second communication will be considered sufficient reason for the dropping of the name, unless the person is known to be alive.

Very respectfully,

RICHARD E. DODGE,
Corresponding Secretary.

RFPORT OF THE RECORDING SECRETARY.

During the year 1904 the Academy met in business session on eight occasions, and the several sections held thirty meetings, at which seventy-six stated papers and lectures were presented upon the following subjects :

Astronomy	2	papers,	1 lecture.
Physics	11	"	
Chemistry	1	"	
Botany	5	"	
Palæontology	2	"	
Zoölogy	10	"	
Geology	6	"	
Mineralogy	2	"	
Physiography	2	"	2 lectures.
Anthropology and Archæology	8	"	
Psychology	16	"	
Philosophy	6	"	1 lecture.
Biography	1	"	

Particular mention must be made of the lecture upon the Physiography of the Alps by Professor Albrecht Penck, an Honorary Member of the Academy.

At present there are 278 Active Members, of whom 132 are Fellows ; the election of one Fellow is pending. During the year two members have died, six have resigned, while six have

been dropped on account of non-payment of dues. As five new members have been elected during the same period, there has been a net loss of nine.

In accordance with a recommendation offered by the Library Committee, a more permanent union of the libraries of the Academy and the American Museum of Natural History has been effected, to their mutual advantage. In regard to publications, it may be stated that the former method according to which papers presented before the Academy could be published in journals other than the Annals with the financial support of the Academy has been set aside. In the future, under an earlier method of publication, a volume of the Annals, to consist of three or four parts, will be issued during a calendar year.

Particular attention is now being given by the Council to the matter of membership, and efforts are to be directed in the near future towards increasing the list of Active Members. As stated above there has been a loss of nine during the year, although the members that resigned exceed the new members by one only. Maintenance, however, is not progressive development unless in the face of adverse conditions. The situation that confronts us is in some respects a difficult one, though not peculiar to the Academy. The special societies, each dealing with some restricted branch of science, will tend more and more in the future as they have in the past to draw away active workers from general bodies such as the Academy. Support for the Academy may therefore be sought with a fairer prospect of success from those upon whom demands are not made by professional duties that their activities shall be centered in the special organizations for scientific work. With such support, publication as one of our two main objects may be furthered. Efforts should none the less be made to draw into the Academy the younger men in active work who must carry forward the activities of scientific nature in the future, thus subserving the second purpose of the Society.

One other subject of general interest must be mentioned. The Council has decided that the routine work connected with the several offices of the Academy shall be performed by a

clerical assistant, with an office at the American Museum of Natural History, who shall be under the general supervision of the Recording Secretary. This arrangement provides for a still further centralization of the activities of the Academy in the Museum, where the Library is already housed, and where the scientific meetings are now being held.

HENRY E. CRAMPTON,
Recording Secretary.

REPORT OF THE TREASURER.

NEW YORK, DECEMBER 17, 1904.

TO THE NEW YORK ACADEMY OF SCIENCES.

Gentlemen: As required by the by-laws, I herewith submit a statement of my receipts and disbursements since my last annual report, and a balance sheet from my ledger, as of this date.

Respectfully yours,
C. F. COX,
Treasurer.

RECEIPTS.

Balance as per last Annual Report		$5,364.62
Bequest of Dr. H. Carrington Bolton for Publication Fund		1,000.00
One year's interest at 4½ per cent. on St. Ann's Ave. Mortgage, $12,000		540.00
Interest on Deposits in Bank		172.67
Initiation Fees		30.00
Annual Dues, 1901	$30.00	
" 1902	60 00	
" 1903	120.00	
" 1904	1,750.00	
" 1905	10,00	1,970.00
Receipts from Annual Dinner, 1903		102.00
		$9,179.29

Disbursements.

Invested in Bond and Mortgage at 5 per cent. on 468 East 135th St.		$5,200.00	
For Publications	$949.18		
Less Sales	87.94	861.24	
Expenses of Recording Secretary		286.57	
" Corresponding "		28.00	
" Treasurer		65.96	
" Librarian		191.01	
General Expenses		79.00	
Assessments of Scientific Alliance		101.07	
Cost of Annual Dinner, 1903		100.20	6,913.05
Balance on hand			$2,266.24
Ordinary Receipts	$2,812.67		
" Expenses	1,612.85		
Gain	1,199.82		
Cash on hand	$2,266.24		
Invested	1,076.07		
Accumulated Income	$3,342.31		

Balance Sheet.

DR.

Investments:	
St. Ann's Ave. Mortgage, $12,000 at 4½ per cent.	$12,000.00
135th St. Mortgage, $5,200 at 5 per cent.	5,200.00
Bills Receivable	130.00
Cash on Hand	2,266.24
	$19,596.24

CR.

Permanent Fund	$11,226.68
Publication Fund	3,000.00
Audubon Fund	1,897.25
Income, Audubon Fund	183.49
" Publication Fund	218.77
" Permanent Fund	1,131.31
General Income	1,938.74
	$19,596.24

New York, December 17, 1904.

REPORT OF THE LIBRARIAN.

To the New York Academy of Sciences:

The status of the Library has changed but little during the last year. The new accessions have been 354 volumes and pamphlets and 2,283 numbers. A detailed and accurate account has been kept of all accessions so that a revision of the exchange list can be undertaken in the near future. Of special interest is the gift from Professor Gustav Retzius of an entire set of his publications. The library is catalogued and open to the public on week days from 9:30 A. M. to 5 P. M.

Respectfully submitted,

R. W. Tower,

Librarian.

REPORT OF THE EDITOR.

During the year 1904 the Academy printed and issued the following publications:

Annals. — Vol. XIV, Part IV, containing a paper by George I. Finlay entitled, "The Geology of the San Jose District, Tamaulipas, Mexico." This was issued in March and consisted of 71 pages, ten plates and one double page map. Vol. XV, Part II, containing the records of the meetings of the New York Academy of Sciences, January 1903 to December 1903, by Henry E. Crampton, Recording Secretary. This was issued in May and consisted of 62 pages. Vol. XV, Part III, containing a paper by Charles Lane Poor entitled, "Researches as to the Identity of the Periodic Comet of 1889–1896–1903 (Brooks) with the Periodic Comet of 1770 (Lexell)." This was issued in December and consisted of 82 pages and two plates.

These papers were mailed to every active member of the Academy. Besides the above named papers the Academy assisted in the publication of a paper by Franz Boaz and a paper by Wm. Jones. These papers appeared in the publications of the American Anthropological Association.

Vol. XVI, Parts I and II, of the Annals and Vol. II, Part

III, of the Memoirs are in press and will be issued soon after the beginning of the year.

Respectively submitted,
CHARLES LANE POOR,
Editor.

THE ANNUAL ADDRESS OF THE PRESIDENT.

Edmund B. Wilson, THE PROBLEM OF DEVELOPMENT.[1]

The selection of such a subject as the problem of development for a general address to this Academy as a whole suggests a word of explanation. Within the privacy of our sectional meetings we are permitted to dig and delve as much as we please among the dry bones of specialization ; but on this occasion a righteous tradition imposes upon the president the duty of laying aside his special tools in order to address the whole scientific body over which he has for a time had the honor to preside. In offering a brief general discussion of some latter day problems of embryology and cytology I shall endeavor not to violate the spirit of this tradition. The task is not an easy one, owing to the complexity of the data and their strangeness to those who have not closely followed the details of modern biological work ; yet I am encouraged to make the attempt by the belief that the problem of development belongs to those

[1] The critical reader will, I hope, be willing to bear in mind the condition under which this address was delivered. My endeavor was to convey to a scientific body, composed only in part of biologists, some individual impressions of a student of embryology and cytology regarding the general bearings of recent researches in his special field. It was not consistent with this purpose to give a critical résumé for biologists, nor could authorities be cited in detail. The general conception here developed will recall certain views contained in Driasch's "Analytische Theorie der organischen Entwicklung," published in 1894 (themselves traceable to earlier conclusions of de Vries), but afterwards rejected by him in favor of an explicit theory of vitalism. The rediscovery of Mendelian inheritance, the newly produced evidence, on the one hand, of morphological and physiological diversity among the chromosomes ; on the other, of protoplasmic prelocalization in the egg, have, however, placed the whole problem in a new light. I wish to acknowledge my indebtedness to Professor Whitman's fine essays on the questions that center in Bonnet's doctrines, published in the "Wood's Hole Biological Lectures," for 1893, which suggested the quotation from Huxley.

larger scientific questions that are of enduring interest to all students of nature. It is only fair to point out, however, that a consideration of recent advances in this subject necessarily and speedily leads us into a region that lies remote from everyday experience, surrounded by arid wastes of technical detail, and inhabited by folk who speak an uncouth foreign tongue. With the best of intentions, therefore, the native guide and interpreter has need of some forbearance on the part both of his countrymen and of the outlanders whom he attempts to lead.

I need not dwell on the absorbing, almost tantalizing, interest with which the problem of development has held the attention of naturalists from the earliest times. Twenty centuries and more have passed since Aristotle first endeavored to trace something like a rough outline of its solution. The enormous advances of our knowledge during this long period have taken away nothing of the interest or freshness of the problem; they have left it, indeed, hardly less mysterious than when the father of science wrote the first treatise on generation. I will not dwell on the epoch-making work of Harvey, Wolff and von Baer, or the curious, almost grotesque controversies of the eighteenth century, when embryology invaded the field of philosophy and even of theology. I will only point out that even at that time, when embryology was almost wholly limited to the study of the hen's egg, embryologists were already occupied with two fundamental questions, which still remain in their essence without adequate answer, and though metamorphosed by the refinements of more modern observation and experiment still stand in the foreground of scientific discussion. The first of these is the question of preformation *versus* epigenesis — whether the embryo exists preformed or predelineated in the egg from the beginning, or whether it is formed anew, step by step, in each generation. The second question is that of mechanism *versus* vitalism — whether, development is capable of a mechanical or physio-chemical explanation, or whether it involves specific vital factors that are without analogy in the non-living world. It is especially to some modern aspects of these two questions that I invite your attention; and I shall

also consider briefly their relation to recent conclusions affecting our theories of heredity and evolution.

Let us first seek to define more clearly the meaning of our terms. The embryologists of the pre-Darwinian period, unhampered by historical conundrums, fixed their attention on the single objective problem of the nature of the germ and its mode of development. The hen's egg contains something which, though not visibly a bird or even an embryo, will when maintained at a temperature of about 37° C. for 21 days, cause a living chick to step forth from the shell. What is that something and what manner of machinery (if machinery it be) is set in motion to work such a marvel? The early embryologists found no real answer to this question. They determined the fact that at the beginning the egg contains nothing even remotely resembling a bird; that as early as the second day a rudely fashioned embryo is visible in the egg: and that day by day, as the incubation proceeds, this embryo becomes more complex. The bird appears to be progressively created out of something that is without form, and void of visible structure. Its development, said Harvey and Wolff, is essentially a process of "epigenesis"—a successive formation and addition of new parts not previously existent as such in the egg. This conclusion, roughly outlined by Aristotle, was apparently established on an irrefragable basis of observation, long afterwards, by Harvey and Wolff. In its superficial aspects the doctrine of epigenesis is no more than a statement of universally admitted fact. When followed to its logical end, however, this conception has failed, and will always continue to fail, to satisfy the mind; and some of the most acute of modern embryologists have expressed the opinion that no thoroughgoing hypothesis of epigenesis can be so framed as to be logical, or even conceivable. Even in the eighteenth century this doctrine was met by the opposing one of preformation and evolution. Advocated by such men as Malpighi, Haller and Leibnitz, this conception underwent its fullest development in the hands of the eminent Swiss naturalist Bonnet. Developed with great logical acuteness and set forth with captivating literary skill, Bonnet's theory was based on the fundamental assump-

tion that the embryo, though invisible, really exists preformed in the egg before development begins. The preformed germ was not conceived to be an exact miniature model of the adult. On the contrary, Bonnet thought of the germ of the fowl, for example, as differing widely in form and proportions from an actual bird, still the original preformation was assumed to be composed of parts that correspond, each for each, to the parts of the chick. Development, accordingly, was conceived to be only the unfolding and transformation of a preëxisting structure, not the successive formation of new parts — a process of "evolution," not of epigenesis. In this particular form the doctrine of preformation was conclusively overthrown by Wolff; but the principle underlying it has repeatedly and persistently reappeared in later speculations on development, and still contests the field of discussion with its early antagonist.

Hand in hand with this controversy has gone one of still more general scope between the two opposing conceptions that I have referred to as mechanism and vitalism. Is development at bottom a mechanical process? Is the egg a kind of complex machine, wound up like a piece of clockwork, and does development go forward like the action of an automaton, an inevitable consequence of its mode of construction? Or, on the other hand, does development involve the operation of specific vital entelechies or powers that are without analogue in the automaton and are not inherent in any primary material configuration of the egg? This question, I hardly need say, is included in the larger one, whether the vital processes as a whole are or are not capable of mechanical explanation. As a problem of embryology it is very closely connected with that of preformation or epigenesis, and in point of fact the two have always been closely associated. Evidently, by its very form of statement, any theory of preformation or prelocalization in the germ assumes at least a mechanical basis for development, *i. e.*, a primary material configuration upon which the form of development in some measure depends. With theories of epigenesis the case is not so clear; for such theories may or may not be mechanical. Without further preamble I now ask your attention to certain

facts which will place clearly before us the form in which these time-honored problems appear to us to-day.

It is a familiar fact that development begins with the progressive segmentation or division of the egg into cells, which, continually increasing in number, finally build up the body of the embryo. Until comparatively recently it was not suspected that the cells thus formed in the earliest stages had any constant and definite relation to the parts of the future body. The fact has now been established, however, that in a large number of forms (though apparently not in all) such a definite relation exists, both the form of division and the prospective values of the cells being constant. In the egg of the ascidian, for instance, the first cleavage-furrow passes pretty accurately through the future median plane of the body, and the two cells thus formed give rise respectively to the right and left sides of the embryo. In a snail's egg the relation is a different one, but is no less definite and constant; in the four-cell stage, for instance, the material that will produce the shell and foot is located, mainly at least, in one of the four cells. Again, in a worm's egg, after its segmentation into sixteen or more cells, we know very exactly how the materials for the head, the segmented trunk-region, the digestive tract, the muscles and the ganglia, are distributed among these cells. In all such cases the embryo seems comparable to a piece of mosaic-work, each cell apparently having its own inherent particular character, and its own specific rôle to play.

These facts place very conspicuously before us a modern form of the problem of preformation which we may conveniently call the problem of "germinal *prelocalization*." Does this mosaic-like character of the early embryo mean that the cells are inherently different? Are they in any degree individually predestined for their future development; and if such be the case, can this predestination be traced back to protoplasmic regions in the egg before it has divided into cells? In other words, does the egg, or does it not, contain prelocalized, predetermined areas that have any necessary or causal relation to the parts of the future embryo? This is the first guise in which the old

question of preformation presents itself to us to-day. I ask you to glance at the results of a few very simple experiments designed to test this question. They will give apparently quite contradictory results.

Experiments on the eggs of certain animals, such as ctenophores or mollusks, seem to give an unequivocal answer to our questions. If, for example, the cells of the segmenting egg of the mollusk *Dentalium* or *Patella* be separated from one another, at the two-cell stage or any later period, they continue to develop and produce living, actively swimming structures ; but these creatures are not completely formed whole embryos, but monsters that in many respects resemble pieces of a single embryo (Fig. 1, *A*). It is true that the wounds usually close and heal ; but these structures, nevertheless, remain monstrous and defective, and if they are carefully studied it is found that only when taken collectively can they be said to constitute a single whole embryo. The cells are thus proved to be in some measure inherently different, and to this extent the cell-mosaic is shown to be a real mosaic. If we now extend our operation to the undivided egg, a result in harmony with this is reached. If certain portions of the egg of *Dentalium* be artificially cut off, the remaining portion, upon fertilization, regularly gives rise to a defective and monstrous creature that is not a whole embryo, but resembles a piece or fragment of an embryo. It is evident that this experiment seems to show pretty clearly that even before the egg has begun to divide into cells the parts of the future embryo are in some measure definitely prelocalized and predetermined in its different protoplasmic regions ; and evidently, if this be the case, we seem further to have good ground for the mechanistic assumption that the undivided egg contains some kind of structural or material configuration upon which the character of the development depends.

But let us not on this account too hastily accept a theory of preformation or prelocalization. Let us first look at the results of an exactly similar experiment performed on the egg of certain other species of animals, for example, *Amphioxus*, a sea-urchin, or a nemertine worm. Separate here the first two or

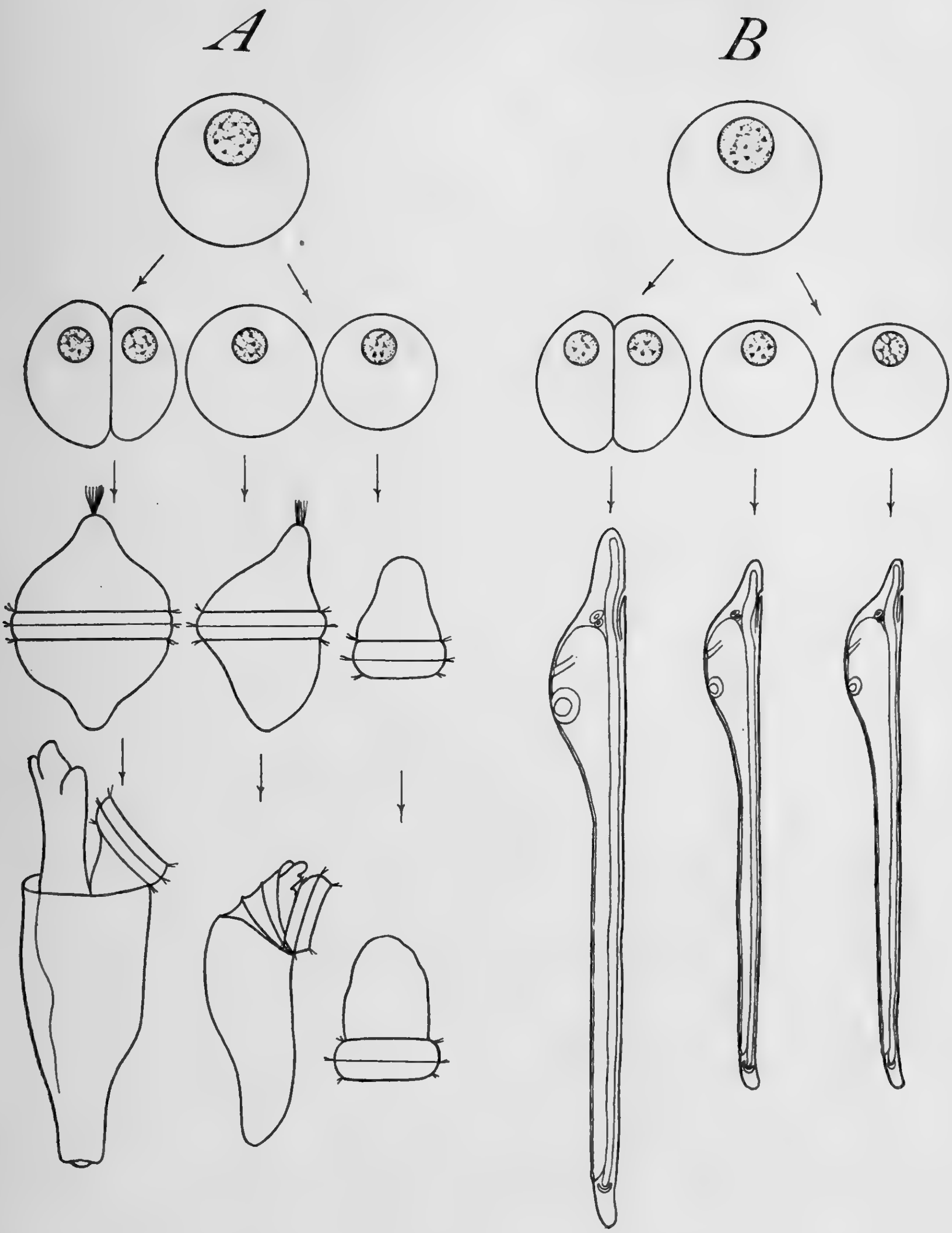

FIG. I. — Development of entire eggs and of isolated blastomeres of two-cell stage. *A*, *Dentalium;* at the left, development of the whole egg; at the right, development of the isolated first two cells, producing two defective larvæ. *B*, *Amphioxus;* the corresponding experiment, isolated cells producing two perfect dwarfs.

four cells, and each develops, not into an abortive monster, but into a perfectly formed though dwarf larva (Fig. 1, *B*). Thus it is possible to produce from a single egg from one to four perfect animals; and in case of certain species (hydromedusæ) it is theoretically possible by a similar method to produce from a single egg as many as eight or even sixteen perfect dwarfs. Again, in some of these cases, for instance in the nemertine, the undivided egg may be cut to pieces in any planes taken at random; yet every piece, if of sufficient size, may upon fertilization develop as if it were a whole egg and produce a perfect dwarf. Here is an astounding contrast to the results of our first experiment. What becomes of our theories of prelocalization here, and what becomes of our mechanical theory of development, if we hold such a theory? Neither the cells nor the regions of the egg seem to have any predestination such as is shown in the molluscan egg. It is the essence of a machine or automaton that its operation is due to its structural configuration. Impair or destroy that configuration and the action ceases. But from these eggs we may take away any of the parts, or the whole may be cut to pieces, yet there is no impairment of action, but only a readjustment to form smaller systems like the original whole. The egg, therefore, says the vitalist, can not be an automaton and its development is inexplicable upon a mechanical theory.

Such is the paradoxical result to which a superficial comparison of these two cases leads us — a kind of embryological antinomy, as it were, which at first sight may seem to take away all hope of finding law or order in these phenomena. I will undertake to show you speedily that the apparent contradiction is easily explicable. I have placed the two cases side by side because each seems to demonstrate the truth of one side of an ancient embryological controversy; and we shall presently find reason for the conclusion that each of the opponents, like the two knights and the shield, have recognized but a part of the truth.

The probable explanation of the difference of the behavior between the eggs of *Dentalium* and of *Amphioxus* is a very simple one. When we closely study eggs of this type we find

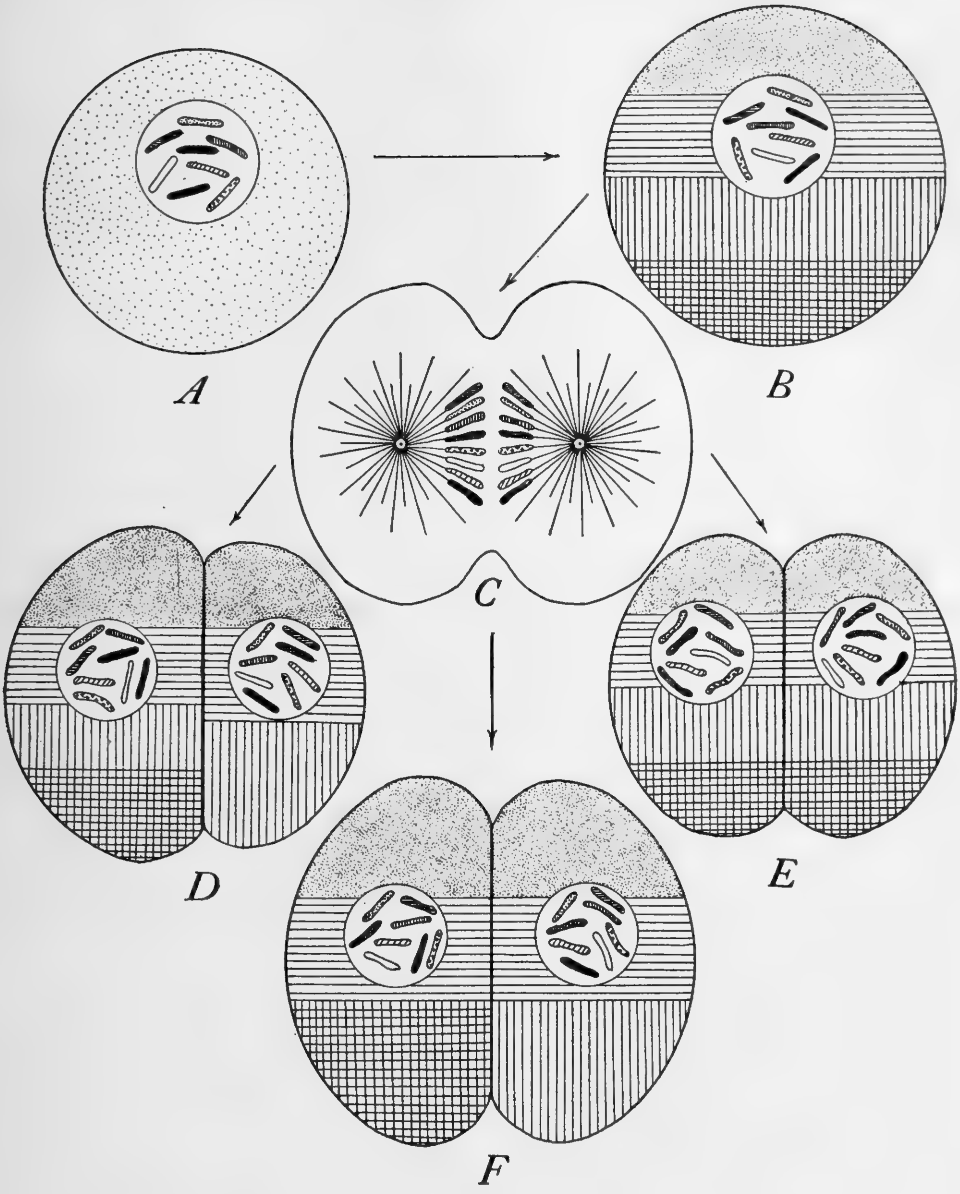

FIG. 2. — Diagram of protoplasmic zones and their distribution at the first cleavage in different forms. *A*, immature egg, assumed to have no definite segregation of protoplasmic stuffs. *B*, mature egg, with protoplasmic zones of horizontal stratification. *C*, first cleavage, division of the chromosomes. *D*, *E*, *F*, different types of two-cell stage. *D*, *Dentalium* type, the lower zone isolated in one cell. *E*, *Amphioxus*, nemertine, or echinoderm type ; equal division of the zones. *F*, hypothetical type with complete separation of two zones at the first cleavage.

that they do not consist of homogeneous protoplasm, but of different kinds of protoplasmic materials or stuffs that are at the outset arranged, roughly speaking, in horizontal bands or strata, as indicated in the diagram (Fig. 2, *B*), where the number of strata is arbitrarily assumed to be four. Now, an examination of the manner in which the egg divides gives strong reason for the conclusion that in such forms as *Amphioxus* the first division bisects these stuffs, so that each of the first two cells receives one half of each stratum (Fig. 2, *C*, *E*). In the egg of *Dentalium*, on the other hand, this is demonstrably not the case, for the lower stratum passes over bodily into one of the cells and is quite excluded from the other (Fig. 2, *D*). The symmetrical division in *Amphioxus*, the sea-urchin, or the nemertine, gives the immediate possibility of producing two smaller systems similar to each other and to the whole egg. The symmetrical or qualitative division in *Dentalium*, on the other hand, does not give such an immediate possibility, for it produces two different systems neither of which is identical with that of the entire egg. It is highly probable that we find here a proximate explanation of the fact that each of the two cells in *Amphioxus* may produce a perfect dwarf, while in *Dentalium* neither produces such a larva. Facts like these are leading us to the conclusion that the immediate determining causes of development are to be sought in specific protoplasmic stuffs, or organ-forming materials, that are distributed to the cells in a definite way during division. These materials, definitely arranged, are sometimes plainly visible in the undivided egg. I have, for instance, been able to show that the egg of *Dentalium* contains an area of protoplasm at the lower pole that has a causal connection with the formation of the foot and shell, and probably also of the principal part of the mesoblast structures ; for if this area be cut off from the unsegmented egg the resulting embryo regularly lacks these structures. In like manner, Professor Conklin has recently been able to recognize in the protoplasm of the unsegmented egg of a species of ascidian the material of the future tail-muscles of the larva ; and though no necessary connection between this material and the muscles has thus far been experimentally proved, my experi-

ments on *Dentalium* leave by analogy little doubt that such a causal connection exists. We do not in the least know how these protoplasmic stuffs or materials act. We can hardly imagine how it is that one kind of stuff involves the development of muscles, others that of nerves, ciliated cells, or shell-secreting cells. We may guess that these stuffs may be analogous to the so-called internal secretions, formed in the adult organism by such organs as the thyroid or the sexual glands, which are known to produce quite specific morphological effects on the body. A second guess is that the formative stuffs may be related to the soluble ferments or enzymes, which in other ways play so great a rôle in the economy of plants and animals.

But, aside from this question, the evidence is steadily increasing, I think, that such stuffs exist, that they have a definite arrangement in the egg, and that in cases where the form of cleavage is constant they are distributed in a definite way to the cells into which the egg splits up. The cleavage-mosaic is accordingly to be conceived as an actual mosaic of different materials that are somehow causally connected with development of particular parts. When these materials are equally distributed by the earlier divisions, as in *Amphioxus*, each of the resulting cells may upon isolation produce a perfect larva; when they are unequally distributed, as in *Dentalium*, the cells are no longer equivalent, and upon being isolated produce the structures corresponding to the particular stuffs allotted to them.[1] These facts will presently bring us to our first general conclusion. First, if the protoplasm contain such stuffs, grouped and distributed in a definite way, to just this extent may development receive a mechanical interpretation — that is, be conceived as the result of an antecedent material configuration in the egg-protoplasm. We have as yet no very distinct idea regarding the degree of complexity of this initial protoplasmic configuration, though there are facts that indicate that it may not be very

[1] It will appear in the sequel that even in the latter case the potentiality of producing a complete embryo may still be present in the nucleus. It is important to distinguish between such primary or original nuclear potentiality, which may be common to all the cells, and the secondary or immediate potentiality determined by protoplasmic specification. The relation between these is still an unsolved problem.

great, *i. e.*, that the prelocalization is of a somewhat general character. This question appears, however, to be of relatively minor importance in view of an additional conclusion given by detailed studies on the formation, maturation and early development of the egg. These studies leave no doubt that the grouping of materials observed at the time the egg begins its process of division is not, in some cases at least, a primary or original one, but is of secondary origin. They indicate further that early in the development the egg contains only a few of these specific stuffs, at the very beginning possibly none, and that as development goes forward new stuffs are progressively formed and distributed. Now, if this conclusion is well founded, the actual progressive development of the protoplasm must be conceived as a process of *epigenesis*, not of preformation and evolution. This is the first general result that I desire to emphasize; and it is in harmony with the fact, on which all embryologists have been agreed, since the time of Wolff, that in its obvious features development is by the formation and addition of new parts not previously existent as such in the egg. The embryo is not actually preformed or even predelineated in the protoplasm from the beginning. The protoplasmic stuffs appear to be only the immediate means or efficient causes of differentiation; and we have still to seek its primary determination in causes that lie more deeply. We are thus led to a brief consideration of the question of the physical basis of heredity, which will direct our attention to an element that has hitherto been disregarded, namely, the nucleus, and bring us to a second general result.

It was long since suggested by Nägeli that there is a particular substance or "idioplasm" peculiar to each species of plant or animal that is transmitted in the germ-cells and has the power to determine the development of the egg according to its nature. Later research has given very strong reason to accept this view in principle, and for the further conclusion that this physical basis is represented by a substance contained within the nucleus and known to cytologists as "chromatin." Passing over the cogent, and I believe steadily accumulating, evidence on which

this conclusion rests, let us ask how the idioplasm is to be conceived. Some of those who have accepted the general conception of the idioplasm have endeavored to think of it as a very complex but still single and homogeneous substance — the frog's egg, for example, might be conceived as containing a frog-determining substance, the human germ a man-determining substance, and so on. The most recent researches are, however, continually strengthening the ground for a quite different conception, indicating that the chromatin does not operate as a simple substance, but is built into a complex fabric having a definite architecture. We are not here concerned with the particular form of this conception developed by Weismann in his well-known work on the *Germ-plasm*, and elsewhere. I am referring to more recent results of observation and experiment which are giving new and more concrete evidence that the nucleus possesses a complex organization, and apparently one that must be conceived as a kind of primary or original preformation, which bears a certain analogy to that assumed by Bonnet, though quite distinct from it.

We may perhaps most readily approach the grounds for this conclusion by considering, first, an example of the indirect evidence drawn from recent experiments on inheritance. I give a single example, typical of a large number of known cases, of the heredity of single or unit characters in the so-called Mendelian inheritance. If pure gray mice be crossed with pure white albino forms, the hybrid offspring are all gray without visible trace of white. But if these gray hybrids be now paired with each other, both parents being gray, approximately 25 per cent. of their progeny are pure white without a trace of gray, and they continue to produce pure white offspring thereafter. Many similar cases are known, the same proportion of approximately 25 per cent. of the "recessive" character in the third generation holding true, sometimes with great precision. What does this prove? First, that the white character is not really absent in the gray hybrids but only masked or concealed — "recessive," in Mendel's terminology; secondly, that the latent white character may in the following generation be completely disentangled

or extracted from the gray; thirdly, since the proportion is definite, that the extraction takes place by means of some definite mechanism. We are at present, I think, unable to imagine an explanation of these truly astonishing facts save by the assumption that the gray and white characters are borne in the egg by corresponding discrete bodies or entities of some kind, that may be mixed and unmixed without fusion, shuffled and unshuffled like cards in a pack. The evidence is so far wholly indirect, though I think none the less cogent. But now, bearing in mind that the case of the gray and white mice is but a single example of a widespread phenomenon, let us ask whether we can actually find any definite structures in the egg, and particularly in the nucleus, that may be assumed to represent such entities. One of the most significant and remarkable discoveries of modern biology is the fact that such entities exist, though it is important not to forget that their significance in heredity is as yet only an assumption, not a completely demonstrated fact.

These entities are bodies known as "chromosomes," and are represented in the diagrams by the rods in the nuclei.[1] I can not within the limits of this address attempt to do more than touch on a few of the discoveries of recent years regarding the chromosomes, though I think they may fairly be claimed to constitute one of the most brilliant chapters in the whole history of biology. The number of the chromosomes is constant in each species and, only with a few exceptions of such a kind as to emphasize the rule, the number in sexually produced organisms is always an even one. It has been proved that during the fertilization of the egg one half of the chromosomes are derived from the father and one half from the mother (Fig. 3, *A*), and the still more suggestive fact has been established — with probability through the study of normal development, with almost complete demonstration through the study of hybrids — that at every division of the egg the chromosomes also divide (Figs. 2, *C*, 3, *B*, *C*,) in such a manner that their progeny are

[1] In point of fact the chromosomes are, as a rule, only distinctly visible at the period of cell-division. In the diagram they are represented quite schematically, as if visible in the resting nuclei.

distributed in equal number, step by step, to all the cells of the body. The remarkable conclusion is thus reached that the fertilized egg, and all the cells derived from it, contain a double set of chromosomes, paternal and maternal (Fig. 3, *D*). The no less interesting result has been experimentally reached that either set — paternal or maternal — is sufficient for complete development (at least as far as the larval stages); for the egg may be caused to develop without the paternal chromosomes, while conversely the paternal chromosomes alone will suffice for the development of an egg from which the maternal nucleus has been removed. Here for the first time we catch a glimpse of the probable physical explanation of the phenomena of dominance and recession that have of late so greatly aroused the interest of experimenters on inheritance; but above all, here is found our first definite basis of observation for the assumption that the nuclear organization is not merely a chemical or molecular one, but represents beyond this some kind of definite material configuration of the nuclear substance.

The time will not allow me to do more than touch on the very recent work that has confirmed and extended this conclusion. It has been found, first, that in some species the chromosomes show constant differences of shape and size, which points towards the conclusion that they may possess specific individual characters. But beyond this indirect evidence, and quite independently of it, Boveri has shown by direct experiments of great ingenuity and beauty that qualitative physiological differences among the chromosomes actually exist: for complete development is only possible in the presence of a particular combination of chromosomes. Hence the conclusion becomes probable that there is a definite causal relation of some kind between the individual chromosomes and the development of corresponding characters or groups of characters; or, in other words, that the hereditary characters are in some manner distributed among the chromosomes which form their physical basis in the egg. We do not yet know in precisely what form this conclusion should be formulated. We do not know, for instance, whether a single unit-character, such as color, is determined by a single chromo-

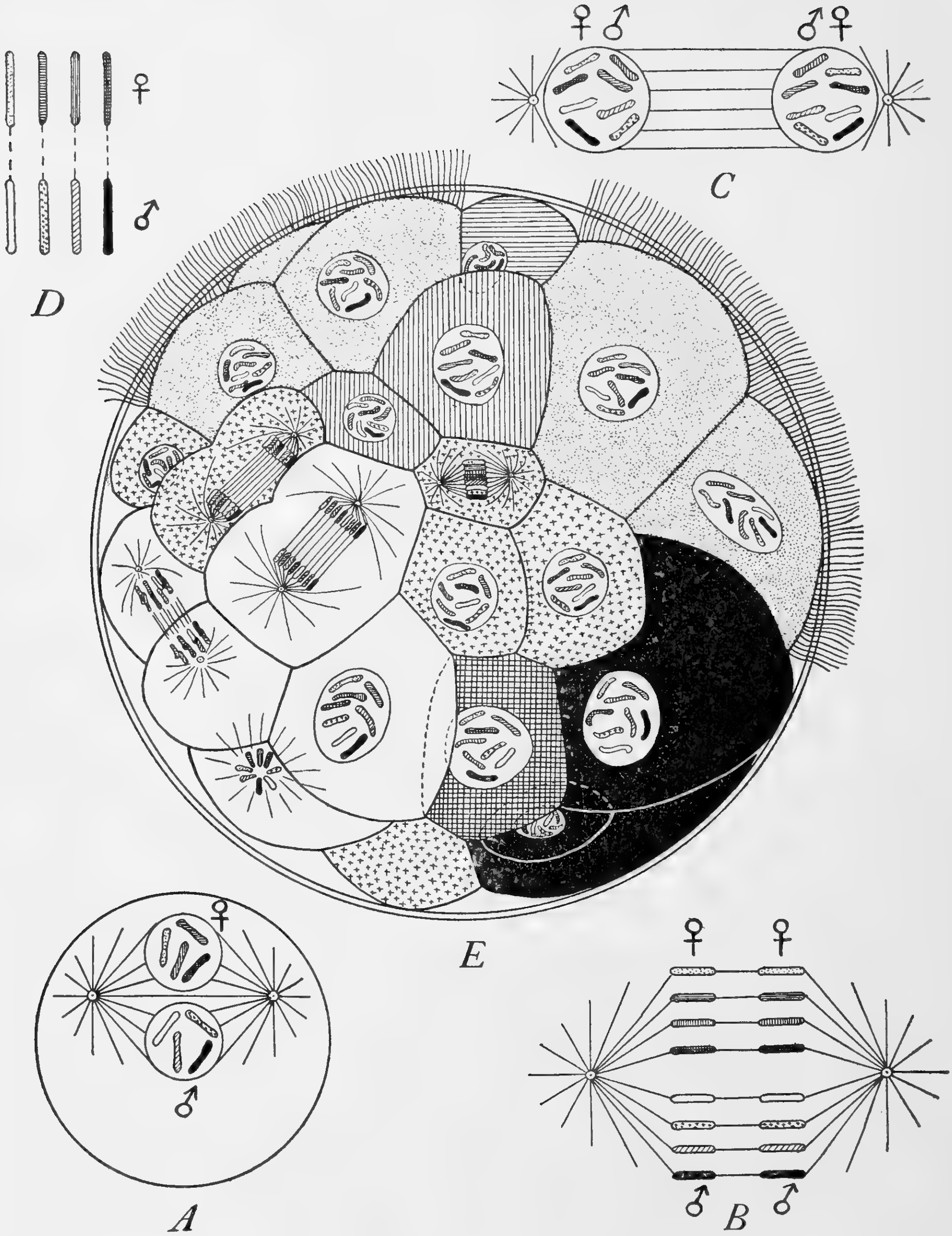

FIG. 3.—Relations of the chromosomes; formation and distribution of protoplasmic stuffs in later stages. *A*, union of the germ nuclei (each assumed to have four chromosomes). *B*, *C*, division of the chromosomes, with equal distribution of the paternal (♂) and maternal (♀) products. *D*, scheme of nucleus at any later stage, with four paternal and four maternal chromosomes (corresponding or homologous chromosomes connected by dotted lines). *E*, actual outline (after Mead) of egg of *Amphitrite* consisting of upwards of 64 cells (nuclei schematized). Entoblast-cells unshaded, primary mesoblast cross-hatched, trochoblasts (ciliated cells) dotted, cells of ventral plate (ventral nervous system, etc.) black; the other cells belong to the ectoblast.

some, or by a combination of chromosomes, or whether this may vary in different cases. In this direction we have taken but the first uncertain steps towards a new horizon of discovery. But the point I wish to emphasize is that if we admit such a distribution of characters among the chromosomes in any measure and in any form, to just this extent have we admitted the principle of preformation as applied to the nuclear substance or idioplasm. To this extent do we admit, for example, that the physical basis of inheritance in a frog's egg is not simply a frog-determining *substance*, but is, in close analogy with Bonnet's conception, a kind of original preformation or microcosm, in which the individual frog-characters are in some unknown manner represented by corresponding chromosome-characters. We can hardly imagine at present how this is possible ; and it must be freely admitted that such a conclusion has an appearance of artificiality and crudeness that almost inevitably creates a certain feeling of scepticism. Nevertheless, to a conclusion similar in principle to this the facts seem to be pretty definitely pointing.

And now, finally, let us see how this conception, if accepted, is to be united with that of specific protoplasmic stuffs, as already outlined. We do not know in any positive way, but we may roughly present the facts to our minds by a kind of artificial hypothesis — somewhat as Ehrlich and his followers endeavor to present the side-chain theory of immunity by means of rough and crude diagrams. Let us assume, for example, that the specific protoplasmic stuffs are formed one after another by means of substances like enzymes that emanate from corresponding chromosomes.[1] Putting the matter in the sharpest and crudest way, let us assume that each of the chromosomes in our diagram is responsible for the formation of the stuff correspondingly shaded. A few of these stuffs, formed and distributed as the egg ripens, determine the initial stages of development. In later stages other stuffs are formed by other chromosomes and progressively distributed to the cells by division. Thus the cleavage-mosaic grows progressively more complex and definite as development advances. Each nucleus still contains the germ

[1] *Cf.* Driesch's "Ferment Fiktion," Analyt. Theorie, pp. 87–92.

or potentiality of the whole organism, but the cells assume specific characters according to the protoplasmic stuffs allotted to them (Fig. 3, *E*).

This attempt to portray briefly the *modus operandi* of development is doubtless an excessively naïve mode of formulating a highly complex and subtle process, concerning the real nature of which we still know very little. Even if literally correct it would still leave quite out of account some of the most important elements of our problem. I do not offer it as a well-established or fully rounded conclusion, but rather as a convenient way of placing before you one fundamental result, towards which I believe the drift of recent research is tending. This is that the germ consists of two elements, one of which undergoes a development that is essentially epigenetic, while the other represents an original controlling and determining element. The first is represented by the protoplasm of the egg. The second is the nucleus, which, as I have attempted to show, must apparently be conceived as a kind of microcosm or original preformation, consisting of elements which correspond, each for each, to particular parts or characters of the future organism. The actual development of the embryo, which is manifested by progressive changes in the protoplasm, is by epigenesis, as Harvey and Wolff maintained. Its primary determination is by means of a preformed apparatus, handed on to the egg from preceding generations in the nucleus, which, though not in any sense a miniature model of the adult, yet somehow embodies in infinitesimal compass, the heritage of the race. And thus the most recent discoveries in this difficult field of research are bringing us to a position which can hardly be better stated than in the words written by Huxley more than thirty years ago: "The process which in its superficial aspect is epigenesis appears in essence to be evolution. . . . and development is merely the expansion of a potential organism or original preformation according to fixed laws." We should not, with the advantage of our present standpoint, read into these words of Huxley's a meaning which it was impossible that he should have had in mind in writing them; yet without yielding to this temptation we may fairly

pay our humble tribute of admiration and homage to a scientific insight that was capable of reaching such a conclusion in the far away prehistoric period when chromosomes and Mendelism were unsuspected, when the nature of fertilization was unknown, and the internal mechanism of development was a wholly unsolved riddle.

I will in conclusion add only a few words on the question of vitalism and mechanism in the light of the foregoing results. In so far as development may be conceived as the outcome of an original material configuration in the nucleus, and a secondary configuration in the protoplasm, it may be conceived as a mechanical process. But it must be admitted that this conception leaves quite unsolved certain fundamental elements of our problem — such for instance, as the manner and order in which the protoplasmic stuffs are formed and assume their characteristic configuration, whether in the whole egg or in the isolated blastomere or egg-fragment; or again, how the wonderful phenomena of the regeneration of lost parts in the adult organism can be explained. We have at present no positive data for an answer to these questions. But it can hardly be disputed that we have already made a considerable advance towards a mechanical solution of the problem, and if this be so, by what right does the vitalist demand that we shall adopt his hypothesis for the portions still unsolved? Let us seek an answer to this question in the answer to a broader one. What is the object of the study of development? I should state this object somewhat as follows: First, to observe and to describe as completely and simply as possible the actual phenomena of development; secondly, to determine to what extent, from its beginning in the egg to its completion in the adult organism, the process can be formulated in terms of the elementary laws of matter and of motion. But this is only a different way of stating that our object is to ascertain in what measure the operations of development, under given external conditions, are the result of an original configuration of material particles in the egg.

Now, I do not need to say that even the approximate accomplishment of these aims is still very remote, their complete

accomplishment impossible. I am fully in accord with the neo-vitalists in their assertion that the phenomena of development and of life generally have not yet been reduced to a mechanical basis, that they can not at present be fully described in physico-chemical terms. It is certain that living beings exhibit structures more complex than any existing in the inorganic world, and different from them in kind. It is possible, probable I believe, that living bodies may be the arena of specific energies that exist nowhere else in nature. I admit fully that the interpretation of development I have endeavored to outline does not exclude, but in some ways actually suggests, the existence of such energies. I should, therefore, even admit that the vitalists are wholly right in their contention that the vital processes are not at present explicable as the direct result of such energies as are observed in the non-living world. To prejudge this question would set up a dogmatic barrier to progress, not only in biology but also in chemistry and physics. If this be vitalism there are probably many of us who must be enrolled as "vitalists," however doubtfully we may regard the honor of bearing such a title. But if the word "vitalism" be used in any other sense than as a convenient phrase, an x by which to designate an unknown quantity, if it be taken in a positive sense to imply in the living organism any negation of the fundamental laws of matter and of motion, the existence of any distinctive entity, or principle that does not fall within the chain of physical causation or that contravenes the general laws of physics, then, I protest, to accept "vitalism" as a principle of interpretation is deliberately to abandon the scientific method in biological study.

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[ANNALS N. Y. ACAD. SCI., VOL. XVI, No. 8, PART III, pp. 387–446
March 1, 1906.]

THE OCCLUSION OF IGNEOUS ROCK WITHIN METAMORPHIC SCHISTS, AS ILLUSTRATED ON AND NEAR MANHATTAN ISLAND, NEW YORK.

ALEXIS A. JULIEN.

(Read before meeting of February 15, 1904)

CONTENTS.

The terms *inclusion* and *enclosure* have been commonly applied to fragments of foreign rocks imbedded within sedimentary deposits, crystalline schists or masses of igneous intrusion. Thus, to take illustrations from structural features on Manhattan Island, New York City, we find here ordinary dikes of pegmatite and aplite included in the upper stratum of micaceous gneisses and schists, which they frequently intersect, running partly along the foliation. Tongues of the schist itself also, or, it may be, lenses and sheets between the crossing dikes, project into the larger masses of intrusive granite in a manner fitly pictured by the broad term, inclusion. The same hard-worked term has also acquired a restriction, in optical mineralogy and lithology, to microscopic enclosures within minerals and rocks.

Need of the Term, Occlusion. — For foreign masses, completely engulfed and enwrapped, whose constituents are consequently in state of reaction and interchange with those of the surrounding country rock and of general absorption into it, there seems to be call for another term which may specifically define relationship to a new stratigraphical unit. Our language is surely for common service. Though the word occlusion has long been in use by our brother physicists and chemists, with reference to envelopment and absorption of fluids, may not the geologist safely borrow it, without danger of confusion, in application to somewhat allied phenomena found in his own field? Its use will tend, I think, toward clearer recognition of the constant passage, alteration, absorption and disappearance of masses of imprisoned rock into a surrounding stratum and of extensive metamorphic changes thereby effected.

Occlusions in Igneous Rocks. — Attention has been directed toward the instances of envelopment of rocks of all classes within igneous dikes and flows and the consequent alteration,

even to total absorption of such enclosures — or, as it has been well expressed, "the striking results of extreme contact metamorphism, displayed by fragments of rocks which have lain for a time in the bath of a molten igneous magma."[1]

In the intimate association of widely diverse types of igneous rocks in the Tertiary of Great Britain similar results to those already noted on Manhattan Island have been recently described — "the tendency of an acid intrusion to follow closely the line of an earlier basic intrusion."[2]

But, in the igneous rocks of Skye, this has resulted, in different cases, in production of "a rock with evident xenoliths, more or less altered, a hybrid product with scattered xenocrysts, usually much disguised, or, in the extreme case, a rock which shows in a given specimen no direct indication of any foreign element. Even this last, however, will often betray its origin by something unusual in its mineralogical constitution."[3] The maximum effects were found where a basic rock had been attacked by an acid magma, especially under one favorable condition, previously pointed out,[4] which has ordinarily prevailed during penetration of a solid body of igneous rock by a fluid magma, that "reactions . . . will be promoted by the former being still at a high temperature when the latter comes into contact with it."

The same observer has thus accounted also "for the continuous or lenticular bands of basic rocks which are in places associated with the more acid and hybrid rocks as integral parts of the complex. These basic rocks appear to have been of the nature of gabbros, now transformed by metamorphism, and in some measure by interchange of material with the acid magma. A dark hornblendic rock of this kind, with more or less evident banding and foliation . . . has the general aspect of a medium grained diorite. In a thin slice it is seen that the deep green

[1] J. W. Judd, *Quart. Jour. Geol. Soc.*, Vol. XLIX, 1893, p. 175.

[2] For instance, the pegmatite dike which can now be seen following the foliation of diorite-schist down the bluff at West 130th Street and St. Nicholas Avenue, Manhattan Island.

[3] A. Harker, *Quart. Jour. Geol. Soc.*, LIX, 1903, 210–212.

[4] *Idem.*, *Jour. Geol.*, VIII, 1900, 394.

hornblende, which makes up more than half of the rock, presents in places the crystal outline proper to that mineral, proving that it is not merely pseudomorphic but has crystallized as such. The rest of the rock consists chiefly of a finely striated plagioclase; but there is also some unstriated feldspar, which may be orthoclase, and a few little interstitial grains of quartz are seen. These last two minerals probably point to a certain impregnation of the recrystallized basic rock by the granitic magma." Other sections presented strings of magnetite granules and a little brown mica.

This description of a diorite schist, known to be directly altered from a basic igneous rock, is almost a repetition of that of the diorite schist of Manhattan Island,[1] indirectly altered after metamorphism. The points of difference are equally significant; the excess of quartz in the latter, from long-continued and thorough pegmatitic impregnation: the state of the iron oxide as hematite rather than magnetite, from the lower temperature concerned in metamorphism: and even the partial separation of bases, lime and iron oxide, represented by zoisite and hematite, probably from the same cause.

On occluded masses of igneous material, the processes concerned have been of two kinds, mechanical and chemical.

Mechanical Processes Attending Occlusion.—The following are the chief effects, as shown on Manhattan Island, of mechanical processes due to agencies of pressure, deformation and shearing.

Flattening into lenticular discs with thin tapering edges; the pegmatite occlusions in particular breaking up into small nodules and lenses, a few inches in length.

Crumpling and corrugation by tangential pressure, in the

[1] A. A. Julien, "Genesis of the amphibole schists and serpentines of Manhattan Island, New York," *Bull. Geol. Soc. Am.*, XIV, 1903, 427–439 The present paper, which is a further development of the same subject, offers the opportunity to record the following corrections to the former:

Page 461, 4th line. For "$.7854\sqrt{d^2 \text{ or } a}$," read "$d^3$."

Page 465, last column, 3d line. Same correction.

Last column, last line. For "d'," read "d'^2."

Page 492, 5th line. For "paucity," read "poverty."

basic schists, usually attended, first, by development of columnar or even fibrous texture under much crushing, associated with symmetrical jointage, and, ultimately, with a granular texture. Under extreme conditions, the diorite schist may become rolled up into isolated cylindrical masses, and, it is probable, sometimes concentrated by thickening, in the direction of the pressure. Good examples of these phenomena have been also noted in occluded masses of diorite, passing into hornblende schist, intercalated in limestone parallel to its foliation, at Jenny Jump Mountain in northwestern New Jersey, concerning which it is stated:

"In some cases it has been seen that these eruptives at a short distance from the contact are banded, and these banded phases, if seen alone, would not be distinguishable from the ordinary banded hornblende gneisses of the region." [1]

Squeezing of a plastic occluded mass outwardly from the margin of a lens along foliation planes of the adjoining country rock. Thus we find our diorite schist often intercalated in several or many thin sheets projected between parting planes of the gneiss in the same stratum, in forms which may be termed secondary or occlusion-dikes. These simulate apophyses of ordinary or primary dikes and even show a limited tendency to intersect thin layers of the gneiss.[2]

Chemical Processes Attending Occlusion. — These vary largely with the relative composition of enclosed igneous material and of contiguous rock. On Manhattan Island the pegmatite seams and lenses are bordered with excess of quartz, often intermixed with tourmaline, apatite, micas, and microcline. At the margin of the basic rocks, the diorite schists, the reactions are still more marked. The hornblende disappears by alteration to biotite, the rock becoming interlaminated with or entirely changed into biotitic gneiss or even biotite schist, with more or less garnet. These layers form gray bands, with the slaty lamination, sharply defined boundaries and often zigzag corrugation, characteristic of the original hornblendic layers. Toward

[1] J. E. Wolff, Rep. State Geol. N. J., 1895, 52–59.

[2] Julien, *loc. cit.*, Plate 63, Fig. 1.

their extremities they melt away vaguely into the adjacent gneiss, rich in both black and white micas, the former probably indicating in large part the final absorption and disappearance, to an unknown amount, of antecedent occluded masses of intruded diorite. The outcrops of diorite schist and of its distinct biotitic derivatives, abundant as they are, afford therefore but a small measure of the number of the original dikes. Dark blotches of indeterminate outline seem to bear further testimony to a vast dissemination of occluded igneous matter and so to the conclusion that the Manhattan stratum was originally seamed through and through by an enormous number of dikes of gabbro, bronzite rock and pegmatite.

Occlusions on Manhattan Island. — Several varieties of these may be distinguished.

Schist Fragments Within Dikes. — Portions of the schists or gneisses themselves are sometimes found to have become separated and enclosed within the margins of intrusive pegmatite dikes, perhaps displaying initial stages of absorption; for example on the knoll in Riverside Park, opposite West 83d Street.

Much more important, as already suggested, have been the results of interchange, in reverse order, from igneous intrusions cut loose during diastrophic movements from connection with their underlying magmatic sources, swallowed up and permanently imprisoned within the invaded schists and there now found in various stages of shearing, alteration and absorption.

Pegmatite Occlusions. — Examples of the acid occlusions have been already sufficiently described. The amount of pegmatitic and quartzose matter thus introduced has been so great that huge masses of saturated gneisses have been converted in part or wholly into bedded granite, well shown still at Mt. Morris Park, at north end of Central Park and on Morningside Heights.

The earliest series of intrusions evidently consisted of rocks of basic and ultra-basic composition, both of which have become almost completely metamorphosed into two present forms.

Quartz-diorite Schist After Gabbro. — The intercalated sheets and lenses of this rock and its variants (hornblende schist, hornblendic gneiss, biotitic gneiss, biotite schist) often charac-

terized by zigzag folding down to minute corrugation, have been elsewhere discussed.

As to its enrichment by quartz, while this has been doubtless derived through general diffusion from adjoining pegmatite masses, its partial indebtedness to internal reaction must be admitted. A common opinion would attribute it entirely to reconstitution of minerals, during passage from a pyroxenic to a hornblendic rock.[1] Most definite evidence on this point has been given by comparison of two analyses, of a dolerite and of its derivative hornblende schist, in the dike at Scourie, Scotland[2] — almost alike except for the gain of two per cent. of silica in the schist.

It will be inferred from previous statements that some forms of our diorite schist have become so thoroughly disguised by metamorphism that only careful study of earlier phases of the transition will enable recognition of the relationship. A rare form in the Woodward Collection[3] is a highly quartzose actinolite-diorite (No. 153, from aqueduct-shaft at West 179th Street and 10th Avenue), which bears to the eye an extraordinary resemblance to an enstatite-diorite, and also reminds one of the constitution and structure shown in the thin section of amphibole-gabbro from Höllmühle.[4]

The frequent distribution of scapolite and wollastonite, in small quantity, among the gneisses of the Island, may yet prove to be of igneous relationship, as in Norway, Canada and the southwestern Adirondacks.

Diorite Bed on Spuyten Duyvil Creek. — Many peculiarities of structure characteristic of an occluded igneous intrusion are illustrated in one bed, as yet undescribed, the largest remaining on Manhattan Island, along the shore of Spuyten Duyvil creek. It has been referred to by Cozzens, in 1843, as the site of a

[1] C. Callaway, *Quart. Jour. Geol. Soc.*, XLIII, 1887, 528.

[2] J. J. H. Teall, *idem*, XLI, 1885, 135–137.

[3] I have been indebted to Mr. Anthony Woodward of the American Museum of Natural History for opportunity to examine his collection of specimens of rocks from Manhattan Island, now at Rutgers College, New Jersey; and to this I shall have other occasion to refer.

[4] J. Lehmann, "Enst. d. altkryst. Schiefergesteine, Atlas," Tafel XXII, Fig. 1.

quarry, and more recently by the United States Geological Survey, in note of its location on the sheet for New York City.[1] Between the last northward turn of that creek and the Hudson river, the extreme northern end of Manhattan Island projects, for a distance of about one quarter of a mile, as a forest-covered rocky promontory, reaching a height of nearly 225 feet above the sea-level.

The following appears to be the succession of beds. The lowest, foliated micaceous gneiss, often slaty in structure, enveloping the sheet of hornblendic rock. Above this, a similar gneiss, with many garnetiferous layers, six to nine decimeters in thickness, much gnarled and contorted. The enclosed roughly crystallized iron-garnets vary from one to three centimeters in diameter. Some layers are white, fibrous and thinly laminated, rich in parallel flakes of a quartz-fibrolite mixture. The highest beds, forming the crest, consist of alternations of micaceous gneiss with layers rendered granitoid by saturation with pegmatite in seams and lenses, often presenting an augen-structure.

Along a slope of 30° which forms the steeper eastern side of the promontory, a belt of hornblendic rock extends continuously, a little above the shore, from a point near 214th Street, for a distance of more than 1,000 feet, until it passes beneath the creek at the northern end of the outcrop. It is intercalated in the bed of foliated micaceous gneiss with generally coincident strike. This gneiss overtops it on the west, forming the summit of the ridge, and also underlies it on the east, along the shore of the creek. There is much fallen talus, but the contact of the hornblende-rock with the gneiss on either side is uncovered in several places, sometimes with so sharp a line of demarcation that one may set one's foot on both rocks at their junction. No difference was distinguished in texture or constitution of either rock near the line of contact. The thickness of the dioritic sheet was estimated at about 35 feet for a large part of its course. The bed of the creek is known to be occupied by crystalline limestone, and a little valley on the east of the

[1] Geol. Atlas of U. S., N. Y. City Folio, No. 83, Washington, 1903.

southern end of the diorite outcrop is also probably underlaid by dolomitic limestone.

Map and Cross-section. — While the general strike of the region, N. 45 to 50° E., prevails over this tract, an eastward bending toward the northern end to N. 61° E., may be due to the influence of the enclosed intrusive mass. It may be here noted that the other great bed of hornblende-schist and serpentine at West 59th Street, whose thickness approximated 30 feet,[1] presented a violent change of course from northeast around to north.[2] Apparently in each case the disturbance may have been a remnant of ancient unconformity, the surrounding gneisses having been later crushed and adjusted into partial accordance with the intruded mass. Changes in the direction and amount of the dip, plotted on the accompanying sketch-map (Plate V) indicate the emergence of a series of sharp folds, the anticlines being partly overturned to the eastward and asymmetrical, their eastern legs being very nearly vertical. Two of these at one point are shown in the cross-section (Plate VI), approximately on the line of 216th Street. In addition, the variations in dip, often nearly vertical, along the eastern margin of the granitoid or pegmatitic micaceous gneiss, which constitutes the crest and mass of the hill, may signify the survival there of another sharp fold. This may imply that the mass composing the western slope is made up of a series of sharply compressed folds, obliterated during pegmatization, with assumption of a new foliation and system of jointage.

Near the center of the hornblendic tract these folds have produced an expansion of the outcrop of diorite-schist to a breadth of more than 200 feet, from which an exaggerated idea of its extent and thickness might be inferred. The exhibition of structure denoting vicinity to the bottom of a syncline (Plate VI), at about 216th to 217th Street, and the low dips at the top of an anticline, near the northern disappearance of the outcrop,

[1] H. Credner, "Die Gliederung der eozoischen (vorsilurischen) Formationsgruppe Nord-Amerikas," Habilitationsschrift, Halle, 1869, 19.

[2] Julien, *loc. cit.*, Map, Fig. 9, p. 488.

signify a pitch of the axes of the folds toward the northeast, directly opposite to the usual pitch in this region.[1]

All the features intimate intrusion of the original gabbro before the folding of the stratum of gneisses, and effacement of the ascending dikes as a natural result of deformation and occlusion.

Petrographic Description. — The rock of the belt consists mainly of thinly laminated quartz-diorite schist or dioritic gneiss, similar to the hornblendic gneisses and schists of the island. It differs however in the general distribution throughout the fine-grained hornblendic groundmass of dull black grains and flakes of hornblende, 0.5 to 3.0 centimeters across, and about 1 to 2 centimeters apart. These mottle its fresh surfaces with black, shining spots and project over the weathered crust in dark lumps, as commonly observed on the weathering of diorites and gabbros. They seem to represent ancient phenocrysts — originally, it may be, of pyroxene — now altered to hornblende, comprising about a third of the hornblende of the rock, and with forms distorted by shearing. Their outlines are generally irregular, rectangular, rhombic, and very often rounded or ovate, producing an augen-structure in miniature. All the indications are of an original rock of gabbroitic habit, certainly without any resemblance to diabase.

The more gently inclined beds at the top of one fold show a coarse banding, made up of light and dark layers, 3 to 50 centimeters in thickness, which suggest bands of segregation or flow. Some of these are accentuated by impregnation with white pegmatite in seams or in ovate nodules, less than a decimeter in length, arranged in parallel planes ; or these may consist of milky quartz or of pure feldspar, often a white plagioclase. Everywhere, however, throughout this bed, there is entire absence of the minor crumpling and corrugation of laminæ of common occurrence elsewhere on the island.

In the general groundmass around the large black grains hornblende predominates, mostly in slender blades or flattened prisms, jet-black and shining, 2 to 5 centimeters long. These are separated by grayish white parallel films, 0.5 to 1.0 milli-

[1] J. D. Dana, *Am. Jour. Sci.*, (3), XX, 1880, 361.

meter in thickness, made up of a mixture of white feldspar and gray quartz, amounting to about 25 to 35 per cent. of the volume of the rock. Much variation prevails in the proportions of the two minerals, one or the other predominating in different ledges. A little black to brown biotite, and still less white mica, garnet and pyrite sometimes occur. No trace of epidote or calcite was anywhere detected ; their absence may be correlated, in my opinion, with that of the sharp minor foldings and corrugations, only produced by intense pressure.[1] Occasionally feldspar and quartz fall short and a thin layer of black hornblende-schist has resulted, with hornblende sometimes in coarse blades, up to 5 centimeters in length. Toward the southern end of the outcrop, where the bed tapers out, the rock becomes fine-grained and more thinly laminated, with hornblende blades rarely reaching 2 millimeters in length, as in the similar, thinly sheared hornblende schists at other parts of Manhattan Island.

In a thin section, under the microscope, the minerals are found to be the same as in other dioritic schists of the island. Hornblende, mostly in prismatic or elongated grains, occasionally in granules or fibrous scales. Twinning common ; maximum extinction 15° to 16° ; $\mathfrak{c} \wedge \dot{c}$. Its rare inclusions consist of rods and spherules of colorless zoisite, plates and twinned crystals of plagioclase, scales of black hematite and rarely brownish red biotite. Plagioclase, abundant in angular particles, showing twinning after the albite law. The low maximum extinction angles, in sections normal to twinning plane, suggest a rather acid feldspar. Apatite and hematite occur as inclusions. Quartz common, in the usual limpid grains. In both feldspar and quartz wavy extinction is very common, sometimes concentric. Occasional cloudy colorless grains were referred to orthoclase.

Joints and Veins. — The mass of schist is intersected by a system of closely contiguous, parallel joints, with general direction N. 5° W. These coincide in direction with well-marked parallel seams of division, often discernible in a hand specimen at intervals of a few millimeters. It is along these planes of

[1] Julien, *loc. cit.*, 446, 493.

weakness that the massive portions of the rock are often traversed by white quartz in minute seams, rarely over 0.5 millimeter in thickness, which weather out in delicate, often reticulating ridges. These plainly denote fine cracks produced by shattering of a brittle mass.

Pegmatite veins or dikes have also insinuated themselves along the same planes in large numbers, parallel or branching and crossing, generally less than 5 centimeters in width, reaching 40 centimeters in one case. Their material consists chiefly of white feldspar, grayish quartz and a little white muscovite, crystallized along the central plane of the sheet, but sometimes only of milky quartz.

It thus appears that the series of three successive igneous intrusions is well illustrated in this bed. Their coincidence at many points is so well displayed that one may cover the contact of all three — diorite, lens of earlier pegmatite and pegmatite dike of the last intrusion — with the palm of one's hand.

Evidence of Unconformity. — The structure just described in these intrusions of basic igneous rocks during Paleozoic time [1] — their intercalation parallel to bedding or foliation of the altered sediments they have entered — is a remarkable feature which prevails throughout the Appalachian belt. It may of course but conform to the suggestive observation in another region that "in such cases the dykes were probably not very different in age from the gneiss which they traverse" [2] — a relation which, if established, may have been connected with inferior superincumbent pressure or with imperfect consolidation of the invaded beds. In one neighboring locality, indeed, they are found in dykes, distinctly intersecting other intrusions or the layers of the associated country rock, viz., those of the Cortlandt Series near Peekskill, New York.

Elsewhere the published evidence on this problem seems to be indefinite and insufficient. As to Pennsylvania we have the statement, "a long narrow belt of sphene-bearing amphibolite schist in the city of Philadelphia . . . cuts across the meta-

[1] J. D. Dana, *Am. Jour. Sci.*, (3), XXVIII, 1884, 386.
[2] Bauerman, *Quart. Jour. Geol. Soc.*, XLI, 1885, 144.

morphic mica schists of the region unconformably and is believed by the author to be a highly metamorphosed intrusive dike of Lower Silurian age. The original augite or diallage has been completely converted into fibrous hornblende, and the influence of pressure is shown in the perfectly laminated character of the schist, in the close foldings produced, and in the minute structure of the rock."[1]

A more satisfactory explanation of the structural character of the basic intrusive rocks at Philadelphia has been given in a recent letter from Dr. Florence Bascom, of Bryn Mawr, Pennsylvania :

"(1) The pyroxenic intrusives, that is, the gabbro, meta-pyroxenite, meta-peridodite (or serpentines), occur in large intrusive bodies. These intrusive masses, in general, follow the trend of the schists and gneisses, but when mapped can be clearly seen to cross the strike of the bedding of the schists and gneisses and to intrude indifferently into the mica-gneiss (Hudson age) and the Pre-Cambrian gneiss. This can be seen from the map, but in the field there are no good contacts. (2) Smaller intrusive basic masses occur which occasionally show contacts. Such an occurrence of a basic dike, now altered to a hornblende-schist, is to be found in the neighborhood of Swarthmore, on the Chester sheet. It strikes nearly parallel to Crum Creek and at an angle to the strike of the mica-gneiss. (3) There are other occurrences of altered basic dikes, now hornblende-schists, in which the hornblende-schist conforms perfectly to the schistosity of the mica-gneiss. In these occurrences the hornblende-schist possesses inconsiderable width and I first interpreted them as altered sedimentary material. Upon further investigation, their petrographic and chemical constitution proved to be similar to that of perfectly well authenticated dikes and led me to consider these occurrences also as intrusive."

In regard to the last case mentioned, intercalation of hornblende-schist in the foliation of gneiss, another possible explanation might be based on relationship of foliation to bedding, as

[1] H C. Lewis, *Nature*, 1885, 560.

suggested by an observation in Delaware county, in southeastern Pennsylvania, on a series of schistose and gneissic rocks considered to be more recent than the Hudson River group, probably altered Devonian: "Throughout a greater portion of the gneissic and schistose belt the cleavage has been, in many cases, mistaken for the bedding of the rock. . . . The cleavage dip varies from 75 to 90 degrees. . . . The true bedding of the measures is nearly horizontal and undulating. The so-called 'bottoms' are more or less distinct lines of separation throughout the gneissic mass, and are the true lines of bedding. These 'bottoms' usually maintain their relative distance from each other and cross the cleavage planes at angles which are usually uniform in each locality. . . . In most of the quarries throughout southern Delaware county the 'bottoms' or bedding is sharply defined."[1] Such distinction of the foliation of schists from their true bedding would of course establish the unconformity of all igneous rocks intercalated along the foliation.

In this connection it has been stated, concerning the gabbros and gabbro-diorites of Delaware: "I have looked carefully for any other evidence of bedding except that coincident with the cleavage, but have found none. The so-called 'bottoms' . . . could not distinctly be made out in Delaware. Planes which might be taken for these were irregular and not continuous and correspond more to joints than to planes of bedding. . . . It must be noted, however, that if we consider the true planes of bedding of the mica-schists to lie nearly horizontal, then the thin outlying lenticular masses of gabbro-diorite . . . which are apparently interbedded with micaceous rock, must be regarded more strongly than ever as intruded bodies, cutting across the stratification. That these rocks are of this character the author is strongly inclined to believe."[2]

On Manhattan Island, in the upper bed of micaceous schists and gneisses, in which the diorite-schists lie enclosed, division-planes and joints intersect the foliation. But those at low angles are occasional, irregular, too obscure to be recognizable

[1] C. E. Hall, Second Geol. Surv. Penn., Pt. I, C. 5, 1885, 2–3.
[2] F. D. Chester, Bull. 59, U. S. Geol. Surv., 1890, 39–40.

in evidence of bedding. If such evidences once existed along those planes, they have become obliterated. The conformity of the limestone-beds to the foliation of the gneisses also apparently indicates coincidence with a common bedding plane.

Outcrop of Gabbro. — Through the courtesy of the Curator, Dr. E. O. Hovey, I have been enabled to examine the series of rocks from New York Island in the collection of the American Museum of Natural History. Two important specimens were found labelled "Syenitic gneiss, West 216th Street and 14th Avenue," in one of which I detected the presence of bronzite. With the kind assistance of their collector, Dr. A. Woodward, and of old maps, I have searched that locality, on north of Inwood Heights, in vain for the out-crop. It was probably a small one and has been apparently covered up with débris during the twenty years which have elapsed. The authenticity of the specimens seems sufficiently established to call for a brief description, on account of their special petrographic importance.

No. 107 is a coarse biotite-quartz-gabbro, fresh and unaltered, closely resembling a biotite-gabbro from Keeseville and coarser norite from Westport, near the Adirondacks, New York, and quite different from the gabbros of Westchester County, New York. It is so feldspathic as to approach a norite or anorthosite, as shown by its specific gravity, 2.778, being chiefly made up of striated grains of greenish gray plagioclase, 10 to 15 millimeters long, whose crystal outlines in many places impart a semi-porphyritic texture to the rock. The dark intervening aggregates, of about the same size, consist of black hornblende; brown bronzite, with silky fibration and high lustre, rarely reaching 15 mm. in length; scales of brown biotite, up to 4 mm. across; abundant grains of gray quartz; and a few shining particles of iron ore.

In thin section, the texture is found to be allotriomorphic. The feldspars form over half the volume and comprise two kinds of plagioclase. The one presents, between crossed nicols, a twinning lineation in rather coarse bands whose large extinction angle indicates a basic variety. The other, with lower index of refraction, displays very fine lineation, often occupying but a

small part of a grain, sometimes crossed by another set of bands after the pericline law; the small extinction angle suggests an acid variety. Quartz grains occur in less abundance, with a few inclusions of black particles, colorless needles (perhaps apatite), chlorite scales, and many sheets of fluid cavities with bubbles. The cracks in the larger grains and the groups of angular granules imply partial crushing and granulation. Wavy extinction prevails in both quartz and feldspar. Zoisite appears in colorless, six-sided to rounded granules, with high relief, scattered sparsely through quartz, feldspar and hornblende — as in the diorite-schist of Manhattan Island[1] — but not in saussuritic form. The ferro-magnesian minerals are also abundant and consist mainly of an orthorhombic pyroxene and three varieties of amphibole. The pyroxene, in brownish white fibrous blades, with parallel extinction, shows an absence of dichroism pointing to enstatite, or in other grains distinct dichroism, colorless to pale yellow, indicating bronzite, through with rare original inclusions. Hornblende, brownish green to yellow, also occurs as a primary mineral, with strong dichroism and absorption; maximum extinction angle 11°. Still more common is a straw-colored to colorless amphibole, the former feebly dichroic; maximum extinction angle 8°. The bronzite and both varieties of amphibole occupy the central part of larger grains which pass at the margin, most deeply at the ends of the fibers, into brownish white amphibole (like tremolite), with its fibration always continuous with the cleavage direction of the inner mineral. This fringe of colorless amphibole is invariably coated by thin filmy wisps of bluish green chlorite, in minute scales and blades, which also stretch out here and there along clefts and interstices of adjoining grains of feldspar and quartz. Sometimes a thin seam of brown biotite, in minute scales, intervenes between the amphibole and chlorite. The fibration of this amphibole is exceedingly fine, often producing the effect of a milky cloudiness; extinction angle, 0° to 5°. It is sometimes filled with black particles of iron oxide and may enclose biotite in elongated scales lying parallel to the fibration.

[1] Julien, *loc. cit.*, 436.

Biotite is also distributed in aggregates of large, coffee-brown scales, intermixed with a little finely granular magnetite. The folia of all these dark minerals show curvature in places as from pressure ; so also the twinning bands in some feldspar grains. Order of paragenesis — bronzite and enstatite, zoisite, brown hornblende, plagioclase, pale amphibole, tremolite with magnetite, quartz, biotite and chlorite. No epidote, olivine or diallage was distinguished.

The other specimen, No. 109, is a still coarser quartz-gabbro-diorite, resembling but not quite so coarse as some gabbros of St. John, New Brunswick, and approaching the facies of a coarse norite of the Cortlandt series. Feldspar for the most part dull white, by incipient decomposition, intermixed with much white and gray quartz. The black ferromagnesian mineral, apparently hornblende, is largely distributed in rude prisms, often over 3 centimeters in length and 8 to 15 millimeters in breadth. Brownish black biotite is abundant, in part rendered brassy yellow by decay. No bronzite appears to the eye, but many grains of garnet, up to 6 mm. in diameter.

It has been a disappointment not to have been able personally to verify the character of this outcrop in place, to make sure that the two specimens had not been taken from half-buried transported boulders. But there are, at least, two earmarks revealed in the microscopic structure of No. 107 which are not in favor of that view : one, the form of the zoisite in isolated crystals, as found throughout the diorite-schists of the island, and not of the saussuritic character common elsewhere ; the other, the alteration rim of colorless amphibole (tremolite ?) around bronzite and hornblende, a feature yet detected only in the gabbros of Delaware, and never any farther northward. Similar double fringes of uralite, tremolite and bastite around grains of diallage,[1] and of tremolite and actinolite around grains of hypersthene and diallage,[2] of bronzite and

[1] L. Finckh, *Zeits. d. d. geol. Ges.*, 1898, 94, 98, 101, 115.

[2] Streng, *N. Jhrb. f. Min.*, 1862, 943, 948, 950 ; J. H. Kloos, *N. Jhrb. f. Min.*, III, Beil.-Bnd., 1884, 24–33 ; G. H. Williams, Bull. No. 28, U. S. Geol. Surv., 1886, 40–45 ; F. D. Chester, *loc. cit.*, 23–25 ; A. G. Leonard, *Am. Geol.*, VIII, 1901, 15.

enstatite,[1] and of olivine,[2] at contact of lime-feldspar, have been observed in gabbros of our Southern States and of Europe. They have been commonly attributed to magmatic reaction before consolidation of the rock — a hypothesis open to question[3] — rather than to change during its subsequent metamorphism.

In this connection reference may be made to a specimen of aphanitic texture, obtained by W. H. Hobbs (*Bull. Geol. Soc. Am.*, XVI, 1905, 169) from Man-o'-war reef in East River, east of Manhattan Island, supposed to be "a dense basalt like that so characteristic of the Newark areas of the Atlantic border. It seems likely that this latter rock may be from a portion of a narrow dike within the series of crystallines." Such an intrusion in this series would be unique, if established. Through the courtesy of Prof. Hobbs I have been supplied with a portion of this specimen, which has been found in thin section to consist of black indurated shale from the basal contact of the Palisades, an altered form commonly distributed in boulders over Manhattan Island and the vicinage of Brooklyn.

Occlusions of Westchester County, New York. — To the north and northeast of Manhattan Island and New York City, similar intrusions are frequently found through Westchester County. Outcrops of pegmatite, diorite or hornblende-schist, hornblende-gneiss, biotitic gneiss and schist and "serpentine," occasionally holding enstatite or bronzite,[4] mark the derivative forms of the eruptives.

At New Rochelle masses of amphibolite and actinolite-schist have suffered partial conversion into serpentinoid, and are associated with coarse black hornblendite, with hornblende in prisms several centimeters in length, hornblende schist, hornblendic

[1] H. B. Patton, Die Serpentin- und Amphibolgesteine nördlich von Marienbad in Böhmen, Inaug. Diss., Wien., 1887, 11, 13, 18; E. Schulze, *Zeits. d. d. geol. Ges.*, 1883, 433; F. D. Chester, Ann. Rep. 2d Geol. Survey Penn., 1887, 98.

[2] Törnebohm, *N. Jhrb. f. Min.*, 1877, 383; F. Becke, *Tsch. min. u. pet. Mitth.*, IV., 1882, 330, 355, 450; R. W. Schäfer, *Tsch. min. u. pet. Mitth.*, XV, 1895, 21; F. Bascom, Maryl. Geol. Surv., 1902, Cecil County, 130–131.

[3] Bascom, *loc. cit.*, 126.

[4] Dana, *Am. Jour. Sci.*, (3), XX, 1880, 31; F. J. H. Merrill, 50th Ann. Rep. N. Y. State Mus., 1896, 40–41.

biotite schist and gneiss, and sometimes steatite. In the hornblendites at New Rochelle and Rye, aggregates of iron-garnet, up to 5 cm. in length, may imply the result of contact reaction between the intrusive rock and adjoining schist. That this reaction has not involved the magnesian limestone of the vicinity, is shown by the absence of lime garnet.

As to the huge boss of granodiorite, seven miles in length, in the town of Harrison, the described mineralogical constitution[1] indicates that this is but a phase of the granite and monzonite of the State Line belt in Pennsylvania.[2] Transition forms by metamorphism appear in the fringe of hornblendic gneisses around that area and perhaps the great tract of augen-gneiss in Bedford.

Passing northward, outcrops of hornblende schist and diorite are met, first reported by Credner, and of gabbros, as at the new Croton Dam, with large pegmatite dikes in Bedford, as well as the common seams and lenses of the earlier pegmatite intrusion.

At the northern end of the county, the well known Cortlandt Series occurs on the southern part of Montrose Point, below Peekskill, as well as across the Hudson river at Stony Point, and at Rosetown, a little further west. This covers an area of about 25 square miles and comprises the following rocks: peridotite (cortlandtite and pikrite); norite with hypersthene (also hornblende-norite, mica-norite, augite-norite or hyperite, and pyroxenite); gabbro (with mica-gabbro and gabbro-diorite); diorite (with brown hornblende-diorite, hornblendite, green hornblende-diorite, mica-hornblende diorite); mica-diorite (with hornblendic and hypersthenic varieties). Diabase has also been reported, and the ultra-basic rocks, magnetite, emery and hercynite, besides metamorphic representatives in the hornblendic gneisses. Dikes occur, cutting through peridotite, norite and limestone, at Montrose, Verplanck and Stony Points.[3] In the Rosetown series, also, numerous small dikes are found around

[1] H. Ries, *Trans. N. Y. Acad. Sci.*, XIX, 1895, 80–86.

[2] F. Bascom, *loc. cit.*, 102.

[3] J. D. Dana, *Am. Jour. Sci.*, (3), XX, 1880, 202.

the edges of the area, where the massive rocks come in contact with the gneiss.[1]

Serpentinoid Outcrops in the County. — Many beds of so-called "serpentine" are distributed through this region north of Manhattan Island. That at New Rochelle has been found rich in partly altered diopside, enstatite (Dana) or bronzite (F. J. H. Merrill), tremolite, often hydrated ("hydrous anthophyllite") and actinolite, with a large amount of carbonates, lying mostly in veins and nests of dolomite, magnesite and calcite. Other accessories are marmolite, brucite, deweylite, chromite, magnetite, spinel and perhaps zoisite.

To the north of Rye an extensive tract of serpentinoid lies near to a ferriferous dolomite. Tremolite, and sometimes actinolite and dolomite, occur in all stages of alteration to hydrated forms, to amorphous serpentine and in part to talc. Pyroxene and chromite have also been recognized (Mather and Dana).

At Portchester, several beds of serpentinoid occur, and small masses with traces of bronzite near Tarrytown.[2] In nearly all these localities this rock has been found with the same associations and alteration-products, particularly steatite, carbonates and limonite, with chert, jasper and chalcedony.

Serpentinoid Ridge on Opposite Side of Hudson River. — On the west, across the Hudson river, and along the very edge of its right bank, ridges of so-called "serpentine," evidently once continuous, stretch for a distance of 14 miles, rising from an elevation of 70 feet at Hoboken, New Jersey, with an area of 30 acres, to nearly 420 feet on Staten Island, with an area there of 13½ square miles.

At Hoboken the actual outcrop extends about one third mile along the river bank, with a breadth not exceeding 300 feet. In the park south of Stevens Institute a knoll of this serpentinoid was formerly exposed, the most southerly extension of the outcrop, with attached coating of a serpentinoid talus-breccia, the cement of the fragments consisting of brown

[1] J. F. Kemp, *idem*, (3), XXXVI, 1888, 253.
[2] Merrill, *loc. cit.*, 40–41.

sandstone. This signified the projection of the outcrop above the level of the Mesozoic Sea, its gradual disintegration and probable extensive degradation. So far as the excavation of the adjoining part of the Hudson River canyon has been possibly connected with erosion of a soft rock, it may be safer to refer this to the visible outcrops of serpentinoid immediately on both edges of the old bluff than to a hypothetical bed of dolomitic limestone of whose occurrence no direct proof has yet been found.[1]

All the evidence points to a volume in the original stratum of this soft and easily eroded rock far exceeding that of the present ridge. The northern end of the mass at Hoboken consists of light green serpentinoid, in part thinly foliated, with eastward dip 75°, toward the river; strike S. 20° W.

In general it presents the uniform fibrous texture usual in rock serpentinoid, with admixture of brucite, marmolite, talc, dolomite, calcite, aragonite, magnetite, chromite and other minerals, mostly hydrated, in veins and seams.

But the coarser mass on Staten Island, at the southern end of this occlusion, whose thickness has been estimated at less than 100 feet, consists largely of ophiolitic amphibolite and gray, green or colorless amphibole schists, sometimes pyroxenic, besides actinolite, asbestus and tremolite rock, passing into serpentine, steatite and talc-schist, chlorite-schist, limonite and cellular quartz-rock. I have determined the specific gravity of two specimens from the point north of Tompkinsville, viz.: dark gray amphibolite, 2.863; light gray tremolite-schist, 2.844.

Descriptions of these serpentinoid outcrops have been already published by J. D. Dana (1880–1881), N. L. Britton (1881), L. P. Gratacap (1887), J. F. Kemp (1887), G. P. Merrill (1889), F. J. H. Merrill (1896), and D. H. Newland (1901).[2]

Some observations concerning the distribution of this sheet deserve consideration. Its southern portion on Staten Island overlies an outcrop of coarse pegmatite for a few rods along the

[1] W. H. Hobbs, *Bull. Geol. Soc. Am.*, XVI, 1905, 176–180.

[2] *Sch. of Mines Quar.*, XXII, 1901, 307–317, 399–410.

shore near high tide level, at Tompkinsville; though its contact with this later intrusion would not necessarily indicate its lower limit. Passing northward, serpentinoid has been found at Constable Point.[1] At Jersey City a layer was met, a few feet in thickness, at the depth of 20 feet, on the south side of the Morris Canal, at the foot of Washington Street; at the Pavonia ferry, at the bottom of a boring of 63 feet; at the end of Long Dock, by a boring at the depth of 179 feet; and in wells on Ninth Street, near Grove Street, at a depth of 700 and 800 feet.

Near the south end of Grand Street, Hoboken, at the depth of 40 feet in the marsh, a well was sunk 360 feet farther, apparently in serpentinoid. At Castle Point, the main outcrop less than half a mile in length along the river bank, descends below the water-level and is supposed "to rest upon the gneiss rocks which outcrop farther south."[2] About one fifth of a mile further north, it is reported to have been found by drilling at a depth of 175 feet.

These notes show great variation in the form, thickness and position of the serpentinoid sheet, perhaps in conformity with sharp flexures usual in the enclosing beds of gneiss. Some suggest the possible existence of another underlying sheet or sill of the same rock. It has been shown by Dana[3] and F. J. H. Merrill that the axes of folds of the Manhattan beds generally pitch gently toward the southwest. As this bed of serpentinoid is located in that direction from Manhattan Island, at the distance of a mile, it may represent, unless brought up by an intervening fault, an intercalation in the uppermost part of the stratum.

Microscopic Characteristics of the Serpentinoid. — The serpentinoid of Staten Island has been already subjected to careful examination in specimens from several localities.[4] Amphibole was found in abundance, associated with serpentine, talc, chlorite, chromite, magnetite, and occasional bronze-colored in-

[1] W. W. Mather, Nat. Hist. of N. Y., Pt. I, Geol. of First Dist., 1843, 284.

[2] I. C. Russell, Geol. of Hudson Co., N. J., 69–70; Mather, *op. cit.*, 603.

[3] *Am. Jour. Sci.*, (3), XX, 1880, 361.

[4] Newland, *loc. cit.*, 313, 316–317.

clusions. The olivine mesh-structure, as well as the rectangular network of diopside, was distinguished in the thin sections, and even remnants of crystals of both minerals.

In the Hoboken rock, the fine texture renders the constitution less easily determinable, and from examination of one variety it was described as "a structureless mass of serpentine fibers." Other minerals distinguished were talc, chlorite, dolomite, calcite, chromite, with small amounts of iron ores. "No traces of the original silicates could be found in any part of the exposure." An analysis by Goodell was presented, without explanation of the low proportion of silica and remarkable excess of lime, both facts inconsistent with the composition of a "rock thoroughly serpentinized throughout."

The results will now be presented, from my microscopic examination of 13 thin sections, prepared from selected specimens of this Hoboken rock, including light green, dark green, compact, laminated and brecciated forms, besides that deposited in veins of marmolite. In even the hand specimens the eye may distinguish a variegation of less altered, dark green spots, and of light green serpentinous spots, and abundantly in both, on certain surfaces, shining green facets, which other observations show to be more or less altered scales of bronzite or bastite.

In thin sections under the microscope a variety of structures present themselves in great distinctness, particularly the knitted or bar structure, the lattice structure and a columnar structure, though never the mesh structure found in the Staten Island rock.

In the tracts with knitted structure brilliant veinlets appear, between crossed nicols, in bent or twisted ribbons, greenish to brownish and orange yellow, with decided pleochroism, colorless to yellow and orange yellow; greatest absorption in direction of the veinlet. Their width rarely exceeds 0.02 millimeter but sometimes reaches 0.04 mm. In the latter case the usual structure is best shown, a central suture or a fine lamination in the plane of the veinlet, with a cross fibration on each side. Occasionally one veinlet is seen to cut across another. The central plane may exhibit thin continuous sheets, separated by a dark line or suture, and is often nearly isotrope (serpentine).

The lateral bands with cross fibration show high interference colors and often a strong pleochroism, pale bluish green and greenish yellow to orange, yellow or colorless. Extinction parallel or normal to plane of veinlet. In places, some veinlets are thicker, continuous and parallel, so as to produce an apparent close lamination, with a micro-augen structure, through the lenticular form of intervening grains of a colorless mineral. This seems to mark, not a schistose structure of the rock, but an eminent cleavage or parting of the parent mineral, probably the orthopinacoid, $\infty P \bar{\infty}$ (100), of diallage. The material of these veinlets may be composite, a mixture of chrysotile and chlorite,[1] or consist of micro-chrysotile, or often wholly of a mineral of somewhat higher birefringence to which the brilliant polarization colors may be mainly due, micro-nemalite, the fibrous form of brucite. Under sufficient magnifying power, the two minerals chrysotile and nemalite, may be easily discriminated by the relative position of their axes of elasticity, $\mathfrak{c}$ lying parallel to the direction of the fibers in chrysotile, and $\mathfrak{a}$ in nemalite. This cross-fibration, in such veinlets within serpentinous rocks, has been hitherto assumed to characterize chrysotile alone. But in this serpentinoid, at least, the incomplete alteration shown in the veins which traverse the outcrop, enclosing brucite partly altered to nemalite and the latter partly to chrysotile, also extends to the microscopic veinlets, which may comprise both micro-nemalite and micro-chrysotile. The general relation of these two minerals is the subject of another investigation.

The interspaces in the knitted or bar structure rarely exceed 0.1 or 0.2 mm. in length, usually predominating in volume of the rock. In places, they are occupied largely by a colorless substance, without relief, cleavage or texture, but which is not isotropic or structureless, as it first appears under low power; or it may be greenish yellow and feebly pleochroic, greenish to yellow. Between crossed nicols it offers an irregular aggregate of blades and plates, with sometimes a very minute platy texture, fibrous in places. Low birefringence shown by feeble interference colors, pale gray or bluish gray to bluish white of

[1] Newland, *loc. cit.*, 317.

the lower First Order, but sometimes reaching reddish orange or bright brown. Extinction of individual blades parallel or normal to chief plane of polarization of the nicols. On selection of small isotropic spots an obscure biaxial interference figure may be shown in convergent light. This substance was identified as serpentine (antigorite) and predominates in some thin sections, but its higher interference colors suggest slight but general intermixture with a more birefringent mineral, brucite.

In many thin sections, irregular colorless patches with little relief occur, sometimes 2 mm. across, connected by narrow veinlets, 0.2 mm. in breadth, generally in parallel arrangement. A distinct pleochroism, colorless to pale yellowish, indicates the predominance of a chlorite. Smaller bunches of the same mineral may occur in apparent isolation here and there. In large part they present aggregates of minute plates and blades of exceedingly fine fibrous texture, microchrysotile or perhaps micronemalite, often with abrupt terminations against the veinlet wall, and revealing in polarized light an abundance of short cross-partings, delicate but sharply defined.

In some veinlets a symmetrical cross-fibration appears, normal to the walls; but the fibers are commonly bent, broken and mixed up, as if by rock movements. A somewhat high birefringence appears in interference colors of upper First and lower Second Orders, from white up to sky blue or turquoise blue.

Prevalent extinction parallel to the fibers and wavy, but varying to 7° in curved fibers. $\mathfrak{c}$ axis parallel to the fibration. In convergent light, the straight bars of a uniaxial figure are commonly seen, most distinct in the more unbroken plates, and very rarely a dim cross opening out on rotation into a biaxial figure. In most cases the direction of the optic axis coincides nearly or exactly with the fibration, *i. e.*, parallel to $\mathfrak{c}$, showing the double refraction to be positive, the mineral being apparently uniaxial.

These chloritic veinlets appear to be the "colorless, low polarizing bands," for which another explanation has been offered.[1]

[1] Newland, *loc. cit.*, 317.

Anomalies in their optical characteristics are partly due to the fine fibrous aggregation and to phenomena of strain, but doubtless in part to a slight but general intermixture with amorphous serpentine, shown in ordinary light by yellow streaks, and perhaps with brucite.

Within the interspaces of the network and imbedded in serpentine, another mineral, colorless to grayish, with some relief often occurs in irregular grains, elongated or lenticular, up to 0.3–0.5 mm. in length, by 0.1 mm. in thickness. They are rarely massive, but finely granular or mylonitic, as by crushing, though more or less indistinct parting planes, perhaps cleavage traces, occasionally appear, even to a platy structure ; these make an angle of 80° to 88° with the parallel serpentine veinlets. Extinction generally wavy, as indeed with all the anisotropic minerals, and imperfect ; maximum about 42°, though in some cases parallel to cleavage. No interference figure in convergent light was obtained. These grains may be assigned to an original mineral constituent of the rock before serpentinization, probably disintegrated diallage, and now make up but a fraction of one per cent. of the volume.

Magnetite is also dispersed in considerable quantity through both diallage and serpentine in these interspaces, in the form of black dust, minute cubes and elongated aggregates, which may reach 0.02–0.06 mm. These are largely gathered along the walls of the interspaces or darken the sides of the partly altered granules of pyroxene.

A very few black particles consist of opaque, rhombic or hexagonal plates, or translucent reddish, orange and yellow scales, referred to hematite.

The lattice structure is less common than the bar structure and usually inconspicuous, presenting cells or interspaces 0.2–0.3 mm. across. Within these, grains of amphibole occur in two varieties.

The one, considered to be remnants of a mineral antecedent to serpentinization, occurs in colorless, broad fibrous sheets and irregular grains, contrasting with the serpentine reticulation by their good relief. They are granular, as by crushing, and rarely

show cleavage traces. Interference colors brilliant yellow of First Order to greenish blue of Second Order ; $\mathfrak{c} = c$. Maximum extinction 16° and wavy. In convergent light, emergence of a negative acute bisectrix is indicated. Inclusions of pleonaste sometimes occur, arranged as if the amphibole represented original grains of bronzite.

A secondary form of amphibole is also found, mostly colorless (tremolite), sometimes pale greenish or bluish (actinolite), with distinct pleochroism, greenish white to colorless or bluish white to pale salmon. It occurs in short prisms, elongated scales, or slender fibrous blades, with cross partings, to 1 mm. in length, with good relief. They may be gathered in clusters or radial groups, or loosely scattered, and may also occupy interspaces of the bar structure. Bright interference colors from yellow of First Order to greenish blue of Second Order. Extinction generally parallel or at angle of 45° to the fibers and wavy, but varies up to 22°. Some grains twinned, with extinction angle about 18°. In convergent light, the emergence of an optic axis appears, with three colored rings. Double refraction negative. Along their margins the crystals are often colored brownish red and yellowish brown by iron ochre. Many are seen to pass into yellow serpentine, and some of the longer blades into talc.

Bronzite appears in allotriomorphic colorless grains, with marked relief, usually mingled with scales of bastite and altered amphibole. It is generally full of irregular fractures and clefts, as by crushing, but in a few instances shows an eminent cleavage parallel to the brachypinacoid, $\infty \breve{P} \breve{\infty}$ (010). In some fragments a slight pleochroism was detected, greenish to yellowish white. Extinction imperfect in the granular form, parallel in the compact, sometimes diagonal and wavy. Double refraction positive. Granules of chromite and pleonaste arranged as original inclusions in this mineral. A peculiar kind of alteration is shown in some thin sections by passage into milky white, nearly opaque material.

Many broad scales, finely fibrous, 1–3 mm. across, were referred to bastite. These are reddish or brownish white and

pleochroic, reddish to colorless, with absorption deepest parallel to fibration. Interference colors brilliant, like those of tremolite, from yellow and deep red of First Order to sky-blue of Second Order. Extinction parallel to fibration ; $\mathfrak{c} = c$. In convergent light, only obscure interference figure, the position of whose axial plane was not determined. Double refraction positive. The scales are usually intersected by veinlets of colorless serpentine in an open network with elongated interspaces, often 0.2 mm. in length, sometimes polygonal with five or six sides, in a kind of islet network.

Other scales, apparently of altered amphibole, resemble those of bastite, and are generally 0.17–.27 mm. in length, often colorless, or greenish and pleochroic, and without relief. These also possess an exceedingly fine fibration and occasionally show cleavage traces in a columnar structure. Interference colors in part like those of amphibole, in part bluish gray of First Order. Extinction in selected spots perfect and parallel, but generally irregular and imperfect, as in an aggregate of altered fibers, and apparently parallel.

Around these grains runs a border, 0.010–0.014 mm. in width, made up of colorless granular tremolite, with marked relief. Much of this is columnar or rod-like, and many rods lie scattered around, as if loosened by movements. Minute veinlets of tremolite also penetrate the grains of amphibole, and granules lie here and there along its fibration. All the features point to steps in the passage of the primary bronzite and its bastitic derivatives into forms of amphibole, last of all into secondary tremolite.

Talc occurs in scattered blades, fibrous bundles and long wisps resembling the sheaves of tremolite, presenting the usual, brilliant interference colors, red, green, etc., of the Third Order. Extinction parallel to the fibers. $\mathfrak{c} \parallel c$. In convergent light, the emergence of an optic axis, with a system of rings, sometimes appears.

Chromite is scattered in jet-black angular grains of finely granular texture and high lustre in reflected light, up to 0.3 to 1 mm. in diameter. Many are irregular in form, rudely rhom-

bic or triangular, or present six-sided outlines like cross-sections of octahedra. Some are mere skeleton aggregates of loosely adhering granules by imperfect development, with hollow interiors occupied by serpentine. Even the massive grains are commonly intersected by sharp clefts filled with serpentine, whose parallelism indicates the plane of strain, coinciding with the schist-plane of the surrounding rock.

Pleonaste is not a common accessory, though very abundant in occasional thin sections in grayish green angular grains, translucent and isotropic, some of which show six-sided outlines. Many granules of chromite are included, sometimes to half or more of the volume of the pleonaste, and the grains of the latter may thus pass along a row into pure chromite and beyond back again into spinel.

Granules of dolomite, with a little relief, are often mixed in the interstices of tremolite or gathered into nests, 0.8 to 2 mm. across, colorless, grayish or reddish white, with clouded margins (by hydromagnesite?). Outlines sometimes projecting, with an obscure fibrous texture, Newton colors along the intervening lines, and many included particles of magnetite. The usual characteristic cleavage and high birefringence. Extinction symmetrical. In convergent light, the bars of an uniaxial cross.

Some clear grains with more relief were referred to calcite.

The paragenetic relationship of the minerals offers the following order: chromite and pleonaste, diallage, bronzite, actinolite and tremolite, magnetite, bastite and hydrous amphibole, secondary tremolite, brucite and serpentine, talc and chlorite, dolomite and calcite, hematite. It has been stated that the mineral of higher birefringence, associated with serpentine and chlorite in the veinlets, must be brucite or its fibrous form, nemalite. Where uniformly diffused, its minute scales or fibers, lying partly in planes normal to the visual direction and therefore isotropic, must blend indistinguishably with its serpentinous matrix of feeble birefringence. This may account for the apparently greater proportion of serpentine observed in the thin sections than that indicated by the chemical analysis. But

where the nemalite is concentrated, as in the lateral bands of the veinlets, with cross-fibration, its higher birefringence and relief betrays its intercalation among the films of serpentine and chlorite.

Genesis of the Serpentinoid Schists. — Four hypotheses have been advanced to account for the origin of the rocks in this western ridge and of their congeners on Manhattan Island and in Westchester County.

First, *Alteration of a sedimentary rock.*[1] There is no longer need of discussion of this view.

Second, *Direct serpentinization of dolomite.* But that mode of reaction and alteration, by solutions carrying silica, though actually observed in the limestones of this region, is here as generally elsewhere a subordinate and limited process. To this, however, has been probably due the origin of the ferruginous, dark green serpentine near Port Henry, New York,[2] as well as, in part, of the serpentine at Montville, New Jersey[3] (and at Rye, Westchester county, New York, according to Dana[4]).

As for replacement by injection of serpentine bodily into dolomite, it has been long ago observed that the conveyance of the mineral serpentine by solutions, if it ever occurs, is very limited in distance.

All such deposits are confined to cracks and cavities within or very near the decomposing silicates from which the mineral has been usually derived. Its transference in quantity therefore and injection into a body of limestone are, I believe, everywhere unknown.

Third, *Alteration of amphibolized dolomite.*

Alteration of a magnesian limestone might pass through two metamorphic phases : amphibolization, the rock becoming penetrated or even replaced by actinolite, tremolite, and other mineral silicates ; and subsequent ophiolitic decomposition, by preliminary hydration and later change into hydrous magnesian

[1] H. Wurtz, *Proc. Lyc. Nat. Hist. N. Y.*, 1870, 102.
[2] G. P. Merrill, *Proc. U. S. Nat. Mus.*, XII, 1890, 597.
[3] *Idem.*, XI, 1888, 105–111.
[4] J. D. Dana, *Am. Jour. Sci.*, (3), XX, 1880, 31.

silicates, in part serpentine.[1] While the prevalence of this process in other regions has been established — Massachusetts, the Adirondacks, Canada, etc. — its insufficiency to account for the phenomena at and near Manhattan Island has been already discussed.[2]

Fourth, *Alteration of ultra-basic igneous rocks.*

The application of this hypothesis to the serpentinoid calls for consideration of its chemical and mineralogical characteristics.

Chemical Composition of the Serpentinoid. — We are indebted to Newland for publication of two analyses of these rocks, and a few others are added below for comparison.

A. "Light green serpentine," Castle Point, Hoboken, N. J. G. A. Goodell.

B. "Dark green serpentine," Castleton Corners, Staten Island, N. Y. Sp. gr. 2.55. G. A. Goodell.

C. "Serpentine," Kallerangen, Germany. G. Schulze.

D. "Reddish serpentine," Lower Predannack, Cornwall, Eng. Sp. gr. 2.77. M. W. Travers.

E. "Wehrlite-serpentine," Lādkīje, North Syria. L. Finckh.

F. "Lherzolite- and pyroxenite-serpentine," Sarikaja Mtns., North Syria. L. Finckh.

	A.	B.	C.	D.	E.	F.
SiO_2	36.90	36.72	40.77	40.29	37.07	39.95
Al_2O_3	1.29	1.06	3.21	5.10	1.70	2.87
Cr_2O_3	.45	.49	2.81	—	—	—
Fe_2O_3	5.79	6.59	1.79	4.94	8.03	11.55
FeO	1.46	1.53	6.12	3.98	—	—
MgO	23.75	29.09	21.24	25.67	38.12	32.05
CaO	15.53	9.95	13.74	11.85	—	—
H_2O	13.14	14.54	10.70	8.17	14.84	13.40
	98.31	99.97	100.38	100.00	99.76	99.82

A comparison of the figures in A and B with those of the published analyses of true serpentines from other regions will serve to establish the wide divergence of Goodell's results and

[1] J. D. Dana, *Am. Jour. Sci.*, (3), XX, 1880, 32; N. L. Britton, *Am. N. Y. Acad. Sci.*, II, 1881, 167, and Nat. Hist. Soc., Staten Island, 1886.

[2] Julien, *loc. cit.*, 449–453.

to prove that the mineral serpentine, played but a small part in constitution of his materials.

The analysis of a serpentinoid from Kallerangen[1] is presented above, as offering a close analogy. That rock occurred in association with hornblende schists and gneisses, chlorite and talc schists, and was pronounced a decomposition product of an aggregate of aluminous tremolite, olivine, and in places bronzite. All of these minerals, together with magnetite, chromite and newly formed chlorite, survived in microscopic particles, and a netted structure prevailed through the thin sections.

A similar composition is shown by a serpentinoid (D) from Lower Predannack in the Lizard district of Cornwall, England, a reddish banded rock, rich in parallel crystals of colorless amphibole. Under the microscope it presented the mesh structure of olivine, and, in some specimens, evidences of enstatite or bastite, and has been recognized as a derivative from a fine-grained peridotite.[2]

Between the long-discussed hornblende schists and "serpentines" of the Lizard district and those of the region near Manhattan Island, certain marked points of difference offer themselves. Here the rocks of both classes are decidedly homogeneous, schistose but not banded, blending together insensibly and often intimately intermixed, and retaining abundant indications of an actinolitic constitution which preceded the alteration into serpentinoid. They seem to be allied to the serpentine sheets but not to the banded hornblende schists of Porthalla in the Lizard district, and to correspond closely to some of the interesting examples of passage of igneous rocks into "serpentine," in the extra-Lizard district, in the west of England, whose phases of alteration have been displayed in numerous published analyses.[3]

Serpentines from North Syria,[4] derived from alteration of

[1] George Schulze, "Die Serpentine von Erbendorf in der bayerischen Ober-Pfalz," Inaug.-diss., Berlin, 1883, 21.

[2] T. G. Bonney, *Quart. Jour. Geol. Soc.*, XXXIV, 1877, 915, and XLVII, 1891, 472.

[3] J. H. Collins, *Geol. Mag.* (Dec. III), 1886, 360–366, and IV, 1887, 220–226.

[4] Finckh, *loc. cit.*, 125–126.

wehrlite, lherzolite and pyroxenite — rocks all free from feldspar — correspond closely in chemical composition with our serpentinoids, though differing in the purely magnesian base of the original pyroxenes.

No feldspar or other mineral of alkaline composition has been distinguished in thin sections of our serpentinoids, nor the "pseudo-mesh structure," indicative of serpentinized feldspar,[1] nor the presence of alkalies in any analysis.. The original constitution of a gabbro, even of a basic type, is therefore eliminated. The poverty in alumina and excess of lime show clearly that the original rock did not consist of an aluminous silicate, such as the aluminous augite or hornblende of an ordinary pyroxenite, limburgite, theralite or similar ultra-basic rock. They are however consistent with the composition of a diallage aggregate.

From a correlation of the results of the chemical analysis with those of the microscopical examination of this serpentinoid, the following conclusions become impressed.

1. The remarkable excess of lime. This is not consistent with the view that "on the assumption that all of the water is united in the serpentine, the proportion of this mineral is to the total mass as about 4 to 5."[2] In the composition of serpentine magnesia is never replaced by lime. It becomes necessary therefore to assign this content of lime entirely to remaining molecules of diallage, mainly left in form of bastite, tremolite and hydrated amphibole.

2. The low percentage of silica. This indicates that a portion of the base must be free from that combination, *i. e.*, magnesia as hydrate, in the form of brucite. A little calculation will show that no possible mode of combination of any silicates of probable occurrence could reduce the silica below 37 per cent., as found in the analyses. It is interesting to note the still lower percentage of silica and higher of magnesia in Nuttall's old analysis: silica 30, ferric oxide 2, magnesia 52, and loss by ignition 16. These figures, if approximately correct, would

[1] Finckh, *loc. cit.*, 109–110.

[2] Newland, *loc. cit.*, 316

indicate a proportion of nearly 30 per cent. of brucite. His specimen was of the usual "dull yellowish green, inclining to olive"; specific gravity, 2.82.[1]

3. Condition of the iron oxides, whether as hematite, magnetite or combined in a silicate. Only a trace of hematite or free iron ochre was found in the thin sections. On digestion of half a gram of the finely pulverized rock in boiling saturated solution of citric acid, it was dissolved in a deep yellow solution. The small grayish residue of gelatinous silica, treated with hot solution of potassium hydrate, yielded traces of undissolved silicates (diallage, bronzite and talc), chromite and magnetite. The last was separated by a strong bar magnet, with apparently no disturbance of the feebly magnetic chromite. It thus became evident that the ferric as well as the ferrous oxide was present in that form in the diallage molecule, as illustrated in many analyses of pyroxene recorded by Dana, who reports "certain varieties containing the trivalent metals, aluminum, ferric iron and manganese. These varieties may be most simply considered as molecular compounds of $Ca(Mg,Fe)Si_2O_6$ and $(Mg,Fe)(Al,Fe)_2SiO_6$, as suggested by Tschermak."

Mineralogical Constitution of the Serpentinoid.— Instead of the predominance of serpentine in our rock, the chemical and microscopical evidences suggest rather an admixture of hydrated forms of ferromagnesian minerals, such as those of which analyses, chiefly from American localities, are tabulated below in the order of increasing amounts of lime.

	Olivine.	Villarsite.	Asbestus.	Actinolite.	Tremolite.	Diallage.	Sahlite.
SiO_2	40.75	38.90	55.20	56.30	57.40	51.41	53.12
Al_2O_3 ...	—	—	—	1.70	.40	4.32	1.06
FeO	9.36	7.80	11.82	4.30	1.40	9.31	6.01
MnO ...	—	—	—	—	—	.04	.60
CaO	—	—	—	10.70	13.90	20.60	23.62
MgO	50.28	47.50	30.73	24.00	24.70	15.14	14.50
H_2O	—	5.80	2.25	1.00	.40	—	.47
	100.39	100.00	100.00	98.00	98.20	100.82	99.38
Analyst.	Manice.	By theory.	Beck.	Seybert.	C. F. Rammelsberg.	W. G. Brown.	Bowen

[1] Nuttall, *Am. Jour. Sci.*, IV, 1822, 16–17.

Remnants of most or all of these minerals abound in these rocks, although, in large part, they are more or less altered and have passed into very minute particles, fibers and scales. In investigating the mineral constitution of the Hoboken serpentinoid, magnetite was separated in the manner already stated and weighed; pleonaste calculated from estimated volume, on part of the alumina; and chromite from percentage of chromic acid found in the analysis.

The presence of carbonates in this rock having been shown by Newland's observations and my own, the loss in Goodell's analysis was fairly referable to the undetermined amount of carbonic acid; from this the carbonates were estimated, chiefly dolomite, with a little calcite and perhaps hydromagnesite. The remainder of lime supplied the basis for determination of the lime-magnesia-iron silicate of a composition intermediate between diallage and augite; for this the analysis of leucaugite

CHEMICAL COMPOSITION OF HOBOKEN SERPENTINOID.

Mineralogical Constitution.		SiO_2 36.90	Al_2O_3 1.29	Cr_2O_3 .45	Fe_2O_3 5.79	FeO 1.46	MgO 23.75	CaO 15.53	H_2O 13.14	CO_2 1.69
Magnetite	.50	—	—	—	.35	.15	—	—	—	—
Pleonaste	.08	—	.05	.01	—	—	.02	—	—	—
Chromite	.69	—	—	.44	—	.21	.04	—	—	—
Chlorite	3.15	1.04	.60	—	—	.16	.94	—	.41	—
Dolomite with calcite and hydromagnesite	3.53	—	—	—	—	—	.77	1.07	—	1.69
Diallage with amphibole and bastite	58.10	28.23	.40	—	5.44	.47	8.17	14.46	.93	—
Serpentine with talc	18.45	7.63	.24	—	—	.47	7.62	—	2.49	—
Brucite with bronzite	8.97	—	—	—	—	—	6.19	—	2.78	—
Water	6.53	—	—	—	—	—	—	—	6.53	—
	100.00									

from Amity, New York, by Harrington, was selected as most suitable, with substitution of ferric oxide for alumina. From the remainder of silica, the amount of serpentine was calculated, on the figures of Garrett's analysis of marmolite from Hoboken. From the balance of magnesia the amount of brucite was estimated. The remainder of water signified the hydration of the greater part of the diallage molecule in the form of the

observed alteration-products, bastite and hydrated amphibole, aside from the remnants of unaltered diallage, actinolite and tremolite. The analysis of the rock with the stated corrections, and its approximate mineral constitution so deduced, are given above.

On separation from the above figures of the percentages of pleonaste, chromite, dolomite and brucite, the molecular ratios obtained suggest that the predominant mineral was a metasilicate, with oxygen ratio *R* : *Si* :: 1 : 2, as in pyroxene, and that the products of hydration are equivalent to an orthosilicate, with oxygen ratio *R* : *Si* :: 1 : 1. The figures are, however, inexact, probably through extensive removal of silica. A similar treatment of Goodell's analysis of the Staten Island serpentinoid has yielded the following results. The amount of carbon dioxide was included by the analyst in the percentage of water and stated to be small.

Chemical Composition of Staten Island Serpentinoid.

Mineralogical Constitution.		SiO_2 36.72	Al_2O_3 1.06	Cr_2O_3 .49	Fe_2O_3 6.59	FeO 1.53	MgO 29.09	CaO 9.95	H_2O 13.42	CO_2 .63	Moisture .52
Magnetite	.20	—	—	—	.14	.06	—	—	—	—	—
Chromite	.77	—	—	.49	—	.23	.05	—	—	—	—
Chlorite	2.79	.93	.52	—	—	.14	.84	—	.36	—	—
Dolomite	1.32	—	—	—	—	—	.29	.40	—	.63	—
Diallage with amphibole and bastite	41.05	18.65	.19	—	6.45	.24	5.35	9.55	.62	—	—
Serpentine with villarsite and talc	41.06	17.14	.35	—	—	.86	17.10	—	5.61	—	—
Brucite with bronzite	7.91	—	—	—	—	—	5.46	—	2.45	—	—
Water	4.38	—	—	—	—	—	—	—	4.38	—	—
Moisture	.52	—	—	—	—	—	—	—	—	—	.52
	100.00										

From these results we infer that in the rock at these localities serpentine plays only a secondary part. Only confusion can result from designation of the mass as a rock-serpentine on the ground of resemblances in chemical composition and physical characteristics. Varieties of such imperfect serpentinization should be preferably discriminated as serpentinoids, in accordance with Von Drasche's excellent suggestion. Nevertheless,

they mark earlier stages in alteration, whose more advanced condition has been reached in serpentinoids occurring southward in the same belt, in Pennsylvania and Maryland.

As to the actual mineralogical constitution of serpentinoids in other regions, while a common view that they are but mixtures of minerals in indefinite and indeterminable stages of alteration will probably be entirely set aside, great differences undoubtedly occur, only to be ascertained by special investigation in each case. The following constitution, for example, has been determined[1] for a serpentinoid derived from gabbro, in Northern Syria: 2 molecules serpentine, 1 clinochlore, 3 hyaline silica. In another, derived from olivine-gabbro, the dark green ground-mass was found to consist of 15 serpentine, 2 clinochlore, 3 amesite, 1 opal, 2 magnetite; while the whitish green *schlieren* were composed of 1 amesite, 1 clinochlore and 13 opal. More closely allied to our own rock is the "pseudo-serpentine" of Washington, recently described,[2] in whose composition silica falls to 13.08 per cent. Its mineralogical constitution was shown to approach the following figures: Hydromagnesite 5, chlorite 14, serpentine 20 and brucite 60 per cent.

Constitution of the Original Igneous Rock. — The exact source of the free magnesium hydrate in our serpentinoid is yet to be sought. Its absence elsewhere from extensive exposures of serpentinized rocks originally rich in monoclinic pyroxene (*e. g.*, in northwestern New York and in Canada), amphibole and talc (*e. g.*, in Massachusetts), makes improbable any connection with decomposition of those minerals in this region. All observations also throw doubt upon the view of derivation, in this case, of brucite and free silica, with or without magnesite, from the breaking up of serpentine in the belt of weathering.[3] Equally unfounded is the assumption that masses of free silica accompanying the serpentinoids owe their secretion in all cases to the process of serpentinization of ferromagnesian minerals. In these

[1] Finckh, *loc. cit.*, 107, 119–120.

[2] F. W. Clarke, *Am. Jour. Sci.*, (4), XV, 1903, 397–398.

[3] C. R. Van Hise, Mon. U. S. Geol. Surv., No XLVII, Treatise on Metamorphism, 1904, 349–350.

brucitic serpentinoids, at least, the facts point rather to genesis from alteration of orthorhombic pyroxene, and of olivine when present, in the original eruptive rock, through dissociation of this magnesium silicate into brucite and quartz, or into brucite, magnesite and quartz, with more or less iron oxide, probably as magnetite, in the case of bronzite or hypersthene. The reactions with bronzite, in my judgment, may be those shown in the following formulas :

$$3Mg_3FeSi_4O_{12} + 9H_2O + O = 9Mg(OH)_2 + 12SiO_2 + Fe_3O_4$$

or

$$3MgFeSi_4O_{12} + CO_2 + 8H_2O + O = 8Mg(OH)_2 + MgCO_3 + 12SiO_2 + Fe_3O_4.$$

In these formulas it has been assumed for the bronzite from the analyses, Mg : Fe :: 8 : 1. A decrease in volume of the resultant products of the alteration is found by calculation in both these cases, approximating 37.9 and 37.6 per cent. respectively. Van Hise has shown that derivation of the same products from serpentine would involve an increase in volume in the two cases of 9.8 and 13 per cent. respectively. The structure of the serpentinoid, however, observed at Hoboken, testifies clearly to general contraction, producing a complicated reticulation of veins (marmolite, brucite and carbonates) and perhaps the jointage, in advance of the schist-seams, gliding-planes and faults developed during later shearing. With the general removal of carbonates and silica, this shrinkage would not be offset by the increase in volume, 0.44 per cent., resulting from alteration of diopside to serpentine, or to bastite, 1.93 per cent.

If my view then be accepted, the relative proportions of magnesia in the amount of brucite and that of the group of other magnesian minerals may serve for calculation of the approximate proportions of bronzite and diallage in the original rock. For example, from the amount of magnesia, 6.19 per cent., contained in the brucite of the Hoboken serpentinoid, and that in the other magnesian derivatives, 17.52, the original pyroxenite

may be reckoned to have consisted of bronzite 26.1, and diallage or diopside 73.9 parts.

In the Staten Island rocks the composition is allied to that of combination of olivine and bronzite with diallage. The predominance of amphibole rich in lime and magnesia, with traces of pyroxene, olivine and bronzite, suggests derivation directly from a basic hornblende schist, derivative in its turn from an ancient diallagite-, bronzite- or enstatite-rock, passing at one point at least into peridotite. The prevailing secondary alteration, *e. g.*, at Pavilion Hill, of diopside into tremolite, indicates an increase in volume of 5.6 per cent., or into talc, of 30.1 per cent., and of olivine into serpentine, etc., 12 to 37 per cent.[1] In this rock the superior proportion of serpentine may give a clue to the original amount of olivine. From the ratio of serpentine to diallage at Hoboken, the proportion of the former at Staten Island would be 13.76 per cent. The excess, 24.72 per cent., would contain 10.44 per cent. of magnesia, mainly due to olivine. From the percentage of magnesia included in brucite, in olivine-serpentine, and in derivatives from diallage, the following constitution of the original peridotite may be inferred: bronzite 21.3, olivine 36.6, and diallage 42.1 parts. These determinations of mineralogical constitution, it will be remembered, apply merely to the specimens represented in Goodell's analyses. At Staten Island, the amount of pyroxenite probably far exceeded that of peridotite.

Phases of Alteration. — The serpentinoid mass on the west bank of the Hudson River and harbor appears therefore closely allied to that on Manhattan Island, at West 59th Street, and of a like basic type — an intrusive sheet or sill of greater dimensions, but of the same constitution, sheared structure and mode of alteration. The metamorphism of these old, more or less basic occlusions has presented two phases.

Where the original intrusion was feldspathic, probably a bronzite- or enstatite-gabbro (like that of Chester County, Pennsylvania[2]), the constitution favored the genesis of diorite,

[1] Van Hise, *op. cit.*, 274–275, 388.

[2] F. D. Chester, Sec. Geol. Surv. Penn., Ann. Rep., 1887, 100–102.

as commonly prevailed throughout Manhattan Island and the neighboring county, Westchester. For this result the influential conditions seem to have been mainly an excess of iron oxide,[1] and partly the presence of alkalies required for development of the black hornblende, syntagmatite, identified in the hornblende schist of Manhattan Island.[2]

Where the ferromagnesian elements, probably bronzite or other orthorhombic pyroxene and diallage, predominated in the original rock, perhaps a pyroxenite, a pure diallagite, or bronzite-diallage rock, as near Baltimore, Maryland,[3] or bronzite-diallage-enstatite-rock, like that of Chester County, Pennsylvania,[4] or in part peridotite, such as the olivine-bronzite-diallage rock or lherzolite of Baltimore County, Maryland,[5] this constitution tended, during metamorphism, toward the development of an amphibolite or smaragdite-rock,[6] often sheared into actinolite and tremolite schist.

In this region these schists were later subjected to hydration by meteoric waters, and then to ophiolitic decomposition, in part by heated waters, with the following processes and products:

1. Partial absorption of water by remnants of pyroxenes, olivine and amphibole, with conversion into bastite, villarsite and hydrated amphibole.

2. Dissociation of bronzite and olivine into brucite and colloidal silica.

3. Solution and removal of colloidal silica and deposition as adjoining masses of compact chalcedony, jasper or ferruginous chert (as also noted in Cecil County, Maryland[7]). These siliceous deposits have not been found on Staten Island, but at Hoboken testify to the more acid composition of the original eruptive rock in the siliceous seams and in the layer of so-called "jasperoid" (Henry Wurtz) formerly visible near the river-level.

[1] J. D. Dana, *Am. Jour. Sci.*, (3), xx, 1880, 26.
[2] Julien, *loc. cit.*, 466–468.
[3] Williams, *loc. cit.*, 58.
[4] Chester, *loc. cit.*, 95–100.
[5] Williams, *loc. cit.*, 54–57.
[6] Williams, *loc. cit.*, 58.
[7] Bascom, *loc. cit.*, 94.

4. Partial leaching out of brucite, magnesite and aragonite into cracks produced by contraction.

5. Partial alteration of brucite into nemalite, recombination with silica and conversion into marmolite and chrysotile.

6. Progressive serpentinization of bastite and amphibole. As in other serpentinoids altered from lherzolite and wehrlite,[1] the process here has been selective, attacking successively olivine, orthorhombic pyroxene and monoclinic pyroxene. The ophiolitic alteration of pyroxene has been generally preceded by its initial alteration into uralite or amphibole, the common step in the process throughout the Appalachian belt [2] as well as abroad.[3]

Lastly ensued the processes of weathering and partial decomposition of the serpentinoid by cold meteoric waters, with distinct products.

7. Superficial disintegration and dissociation of the rock into ferruginous quartz, colorless, greenish and reddish [4] and into limonite. This action has been deepest at several places on Staten Island. The distinction of the two kinds of siliceous deposits,[5] the semicolloidal (siliciophite of Schrauf) and the crystalline, near serpentinoid beds, does not appear to have been always recognized.

8. Occasional slight concentration of chromite, magnetite, and perhaps spinel.

9. Talcose and chloritic alteration of amphiboles, with separation of lime and magnesia carbonates, in particles and veinlets of calcite, dolomite and hydromagnesite, with concentration on Manhattan Island, at West 59th Street, as ophicalcite in cavities of the serpentinoid.

Pegmatite Occlusions on Opposite Side of Hudson River.— The early process of saturation of the schists of Manhattan

[1] J. Ball, The Serpentine and Associated Rocks of Davos, Inaug. Diss., Zurich, 1897, 15.

[2] F. Becke, *Sitzber. d. k. Akad. d. Wiss.*, LVI, Beil.-Bnd., Wien, 1867; Williams, *loc. cit.*, 45–49, 56–57; A. G. Leonard, *loc. cit.*, 163.

[3] Collins, *loc. cit.*, 360.

[4] Honeycomb quartz of T. Rand, *Proc. Acad. Nat. Sci. Phila.*, 1880, 241, and 1900, 311; in Maryland, by decay, the soil known as honeycomb soil, Bascom, *loc. cit.*, 95.

[5] Finckh, *loc. cit.*, 140.

Island with pegmatite and quartz, in seams and lenses along the foliation, has met with one curious exception which calls for explanation — the beds of actinolite, tremolite, talc, chlorite and serpentinoid. The complete absence of such occlusions from these, and even of siliceous increment in chemical composition, stands in strong contrast with the swarm of quartz and pegmatite lenses in the adjoining beds of gneiss and quartz-diorite. This freedom from pegmatitic occlusions prevails also in the serpentinoid of the Hoboken-Staten Island ridge, and, I believe, in the similar rocks of Westchester county. Whenever free silica occurs, this is merely a late product of alteration or of decay, secreted as chert during brucitic or ophiolitic decomposition of a pyroxene or amphibole, or as cellular quartz enclosing limonite, during subsequent decay.

The explanation of this fact may lie in the impervious textures of the original pyroxenite and of the tough and pliant, derivative amphibole schists. Those developed from the gabbro, however, rich in hornblende and feldspar, became brittle and even granular under the kneading of orogenic movements and flexures, and their shattered masses admitted free permeation by pegmatitic injections.

Granite Dikes Underlying the Serpentinoid. — An outcrop of coarsely foliated pegmatite on the shore at Tompkinsville, Staten Island, furnishes evidence of an extensive pegmatite intrusion underneath the serpentinoid ridge. A little further north, at the mouth of the Kill van Kull, the blasting of a reef in the harbor enabled Dr. Arthur Hollick to make a collection which consists entirely of coarse and fine-grained pegmatite, sometimes distinctly graphic, and occasionally a well-laminated gneissoid granite. The latter structure, probably marginal, must have resulted from movements while the igneous mass was still in partially molten condition. According to one hypothesis, this was due "to the drag of the stiffly viscous granite magma along its walls during its intrusion,"[1] or, according to another, "to the strain of the viscous magma upon separated crystals where

[1] W. O. Crosby, *Tech. Quart.*, Boston, XII, 1899, 95.

the temperature was lowered as near faces of a fissure."[1] Reefs and islets in New York harbor have also been found to consist of remnants of pegmatite dikes and of the gneisses which predominate over Manhattan Island. Granite was struck at a deep boring in Hoboken, and behind that city, at side of the Weehawken hill road, in an outcrop "underlying the red sandstone."[2] The latter reference, however, is open to the suspicion that it may have related to the so-called white "arkose" or bleached Mesozoic sandstone, often found below the trap in that vicinity.

The significant inference from these observations is that the basic intrusion in the gneiss, now forming the ridge on the west bank of the Hudson, was followed, as on Manhattan Island, by intrusions of pegmatite. These found the tough material of the overlying basic sill impenetrable, except perhaps on the north line of the present Kill van Kull. Along this plane of weakness, after elevation, the ensuing erosion of the acid rock resulted in excavation of the mouth of the Kill and in separation of part of the serpentinoid ridge, on Staten Island, from its continuation on the mainland at Jersey City and Hoboken.

Occlusion Tracts along the Appalachian Belt. — Intrusions of the same general character and apparently of the same age have been traced through the belt of crystalline schists all along the coast, as far south as Alabama. It seems desirable to review briefly certain results, at some points along this course, which correspond to observations on Manhattan Island on processes of occlusion.

Maryland. — The Piedmont plateau in this State presents two distinct tracts[3] of highly tilted schists in approximate parallelism to the coast line. The western consists of semicrystalline schists — slate and phyllite, limestone and marble, sandstone and quartzite — regarded as metamorphosed Palæozoic sediments (Cambro-Silurian); the eastern, of holocrystalline

[1] T. G. Bonney and C. A. McMahon, *Quart. Jour. Geol. Soc.*, XLVII, 1891, 483–490.

[2] I. Cozzens, A Geol. Hist. of N. Y. or Manh. Isd., 1843, 40–41.

[3] G. H. Williams and C. R. Keyes, *Bull. Geol. Soc. Am.*, II, 1891, 301–322

rocks, in part of detrital origin — mica schist and gneiss, dolomitic marble, quartzite and banded biotite-muscovite gneisses — displaying the same petrographic facies and sequence as at Manhattan Island, with similar extreme plication, and also penetrated by vast quantities of eruptive materials.

The correlation of these crystallines from the Washington to the New York area has been recently so clearly defined[1] as to require no repetition for my present purpose. But the inference that the differences in alteration of the rocks of these two tracts in Maryland, and among the same crystallines along the Appalachian belt, have been due to contact metamorphism, is, in my opinion, for many reasons improbable and untenable. It would appear rather as a belt of orogenic disturbance and metamorphism, to which the eruptives themselves have owed their more extensive extrusion and through which they have shared deformation and change with the sediments they invaded. They have been classified under three types :

(1) Intermediate, the most ancient, consisting of hypersthene-gabbro, gabbro-diorite passing into hornblende schist, quartz-gabbro, norite, diorite, hornblendite and hornblende-biotite-quartz-gabbro. (2) Basic, comprising pyroxenite, lherzolite, cortlandtite and serpentine. (3) Acid, comprising binary granite, granitite, hornblende-granite, granite-porphyry, augen granite-gneiss, felsite and pegmatite. It is further stated : "The areal distribution of these gabbro masses . . . is believed by the author to indicate that the various occurrences represent what was once an immense gabbro sheet extending from Laurel, Maryland, to the Schuylkill river, a distance of fully 85 miles, with an exposed breadth of at least 15 miles. Through this great sheet of gabbro were apparently intruded the granites and later metarhyolites and pegmatites, the whole constituting one great series of igneous activity."[2] Reference has been made[3] to the close alliance of these intrusives to the more limited series at Manhattan Island, and to the more complete metamorphism

[1] E. B. Mathews, *Am. Jour. Sci.*, (4), XVII, 1904, 142–146.

[2] Matthews, *loc. cit.*, 155.

[3] Julien, *loc. cit.*, 485–486.

of the latter from intricate folding and intense compression. Although Williams remarked on the scarcity of quartz in the first two of the above types, quartz-bearing gabbro has since been found[1] at several points near Baltimore, the quartz occupying from 10 to 33 per cent. of the whole rock, and in Cecil county even quartz-diorites and tonalites have been recognized. A recent examination of the igneous rocks of that county[2] has confirmed the evidence of magmatic differentiation, resulting in a central body of intermediate activity, penetrated by intruded material both of greater acidity and greater basicity, in the following succession: Basic granite (biotite- or hornblende-quartz-monzonite), sometimes altered to gneiss, containing dikes more acid in character, altered to meta-rhyolite; quartz-biotite-hornblende-gabbro;[3] quartz-hornblende-gabbro, altered also to meta-gabbro and meta-quartz-gabbro; hornblende-norite and quartz-norite; norite and hypersthene-gabbro; pyroxenite and peridotite, altered also to amphibolite, serpentine and soapstone. With the serpentine amphibole schists are associated, containing asbestus, tremolite, anthophyllite, actinolite or chlorite, and represent the metamorphism of pyroxenites. The granite is crossed by throngs of gabbroitic dikes, a reversal of the relationship established elsewhere in the belt and on Manhattan Island. A prominent center of this ancient eruptive activity in Maryland lies close to the site of the city of Baltimore, which stands on the edge of the crystalline tract, where it is crossed by the Patapsco river.

Delaware. — In northern Delaware a series of crystalline schists, known to be of Cambro-Silurian age, offers "the most complicated and striking examples of contortion."[4] These comprise micaceous schists which lie above the Trenton and possibly above the Hudson river schists; a highly crystalline magnesian marble (Calciferous limestone); and a coarse quartz-

[1] U. S. Grant, Johns Hopk. Univ. Circ. No. 103, 1893.

[2] Bascom, *loc. cit.*, 83–148.

[3] The analysis by Hillebrand (Bascom, *loc. cit.*, 124) approximates that of the quartz-biotite hornblende schist of Manhattan Island (Julien, *loc. cit.*, 439).

[4] F. D. Chester, *Proc. Acad. Nat. Sci. Phila.*, XXXVI, 1884, 237–249.

itic rock (Potsdam). The close correspondence to the succession on Manhattan Island is apparent.

These beds have been invaded by an extensive group of intimately related igneous rocks, presenting the following facies;[1] primary hypersthene gabbro, often with brown dichroic hornblende, passing into gabbro-diorite, hornblende-gneiss and hornblende-schist; into gabbro-granite, by addition of biotite; into norite, with excess of feldspar and quartz; into gabbro-diorite, by paramorphism of pyroxene to green hornblende; into gabbro-diorite and hornblende-gneiss, by addition of green hornblende, and this into epidotic diorite, by epidotic alteration of feldspar; an intrusive serpentine also occurs.

In regard to the distribution of quartz, it was noted that in the gray trap, "the rock is composed of plagioclase-feldspar and hornblende, with frequently a small proportion of blue quartz and biotite. Massive hypersthene often entirely replaces the hornblende." . . . The rock thus ranges from a quartz-diorite to a true hyperite. "The chief distinguishing feature of the Delaware gabbros is their highly acidic character, due to the large admixture of quartz." The hypersthene-gabbro, or so-called "blue granite," "is normally a finely granular mixture of basic plagioclase, hypersthene and diallage in nearly equal proportions, with accessory quartz, magnetite, apatite, hornblende and biotite. . . . The rock is a most unstable form, running on the one hand into a rock possessing strongly the character of a granite and on the other into those distinctly dioritic." "That these massive rocks have been subjected to great pressure is shown by mechanic deformations in a crushing of the quartz and in an occasional bending of the mica laminæ." The gabbro granites show all degrees of semi-foliation "through increase of biotite with probably accompanying pressure," with production of *flaser*-structure and passage into schistose gabbro-diorites and hornblende-gneisses. The rocks described are of the same general character as in Maryland and offer the same genetic relationship, but under pressure-conditions which approached more closely than at Baltimore to those which prevailed on Manhattan Island.

[1] F. D. Chester, U. S. Geol. Surv., Bull. No. 59, 1890, 1–43.

At the crossing of the broadest part of this belt of massive gabbros and hornblendic derivatives by Brandywine and Christiana creeks, the city of Wilmington is situated.

Pennsylvania. — A still closer correspondence in metamorphic forms and structures of old igneous occlusions is met in a tract of crystallines which lies still nearer to Manhattan Island. In the vicinity of Philadelphia crystalline gneisses and schists occur, attributed to alteration of Cambro-Silurian sediments, and are in large part identical with those of Manhattan Island.[1] A similar succession has also been determined, the highest stratum being micaceous, comparatively soft and very schistose; this overlies a crystalline limestone; and beneath follows a hard and more quartzose gneiss.[2]

These schists are penetrated by many igneous occlusions, in part of more or less basic type, like those whose former existence on Manhattan Island has been inferred from the derivative schists. For example, on the Chester Creek section, gabbro and pyroxenite (Rand, p. 291); "near Aldham, a gabbro in a very distinct dike about 100 feet wide, with porphyritic feldspar crystals"; dikes of norite (Rand, p. 327); in Willistown township, massive enstatite or bronzite (Rand, p. 311), etc. Analyses of diorite and hornblende slate, as well as of hornblende picked out from these rocks[3] approximate the results obtained on corresponding specimens from Manhattan Island.[4] With these intermediate or basic types of igneous rocks, acid varieties are associated in the form of pegmatite, aplite and granulite, and it has been affirmed: "All the rocks of this belt can be traced back to an original pyroxenic magma erupted through the azoic schists which surround the belt."[5]

The alteration products, however, of these definite igneous types are more common and closely resemble those on Man-

[1] J. D. Dana, *Am. Jour. Sci.*, (3), xxi, 1881, 439; and F. J. H. Merrill, *idem*, (3), xxxix, 1890, 387.

[2] T. D. Rand, *Proc. Acad. Nat. Sci. Phila.*, 1900, 221.

[3] A. G. Leonard, *loc. cit.*, 141, 144, 146.

[4] Julien, *loc. cit.*, 439, 468.

[5] F. D. Chester, Second Geol. Surv. Penn., Ann. Rep. 1887, 105.

hattan Island and their association with micaceous gneisses.[1] Thinly foliated hornblende-schist and gneiss are of common occurrence (Rand, p. 261), and have been thus described by Rogers: "Metamorphosed with characteristic white streaks of imperfectly developed crystallized feldspar and hard hornblendic material, with roundish specks of semi-crystallized feldspar. . . . Remarkable for the regular parallelism of its lamination and bedding; the laminæ alternately light and dark, being exceedingly thin, many of them usually packing within the thickness of an inch. In some of the layers certain laminæ are studded with isolated crystallizations of hornblende." "Occasionally the rock approaches a porphyritic gneiss in aspect. . . . This has much to suggest an igneous origin; much of it is a true augen-gneiss. . . . It seems to resemble very closely the augen-gneiss near Bedford, New York" (Rand, p. 278).

The close association of groups of thin layers of hornblendic schist, like sheared apophyses from a dike, observed on Manhattan Island,[2] finds its analogues in this region: "Alternations were observed of very soft schistose layers, one to eight inches thick, of decomposed gneiss and mica schist, with layers of small hard angular blocks of very hard, gneissoid gabbro-diorite. Of the latter sixteen were observed in a space of eight feet. . . . One dike (?) of it is about four feet in width" (Rand, p. 288).

These hornblendic schists show the same transitions as on Manhattan Island to epidotic varieties; biotitic granite; highly feldspathic gneiss, containing but little biotite or hornblende (Frankford gneiss); biotitic gneiss, rich in black biotite, passing into "a very quartzose biotite-schist, the layers being very well defined and often 20 or 30 to the inch, and these layers excessively plicated" (Rand, pp. 277, 302).

As to the serpentinoids, observations have shown that they are all of the same geological horizon and mostly derived from alteration of peridotite, amphibolite or pyroxenite (bronzite or

[1] Rep. Prog., Second Geol. Surv. Penn., C6, pp. 28, 30, 92, 93, 101, 102, 114, 132.

[2] Julien, *loc. cit.*, 471–474, 493.

enstatite rock); near Glen Riddle, some of the serpentine is after actinolite (Rand, p. 316). "It was my aim to distinguish the hard, nearly black serpentines, derived chiefly from enstatite or bronzite, . . . from those of a lighter color, with less serpentine proper and with talc, steatite and antholite . . . probably altered peridotites in large part," containing pseudomorphs after olivine (Rand, p. 304). Reference is made also to "slaty serpentine, very dark olive green, and sometimes almost black in color," associated with schiller-spar and enstatite;[1] or with "asbestus, enstatite and quartz, the last resulting from the alteration of the serpentine."[2] The talcose serpentinoid derived from peridotite has been designated a perido-steatite.[3] It is of interest to note that the same variations prevail in the serpentinoid at Philadelphia as at New York City, and that the two distinct kinds, above referred to, are found in different parts of the same Hoboken-Staten Island outcrop.

At Philadelphia then, at the crossing of this belt of igneous occlusions by the Schuylkill river, we find the location of another great city.

Massachusetts.—We owe to the investigation of numerous local petrographers a good knowledge of the series of crystalline formations which make up the Boston basin, and many of which display traces of the fluent structure of ancient volcanic lavas, some of which have been extravasated upon the surface. Dike structure is of very common occurrence. They comprise an extensive series of acid eruptives, granite, felsite, petrosilex and porphyries, as well as more or less basic exotics, norite, diabase, diorite, hornblendite, hornblendic gneiss and other metamorphic forms; these have been in part attributed to Huronian age. The correlation of these classes has been established at several points in the basin, and their development by differentiation from a common magma. The basic varieties are most fully distributed on the north of the present site of the city of Boston, though to less extent on the west and south,[4] where acid forms prevail.

[1] Rand, *op. cit.*, 1876, 3. [2] Rand, *idem*, 1880, 241, and 1890, 118.
[3] Bascom, *Proc. Acad. Nat. Sci. Phila.*, 1896, 219.
[4] W. O. Crosby, Occl. Papers, Bost. Soc. Nat. Hist., III, 1880.

Location of Cities Along the Occlusion Line. — Attention has been called[1] to the position of Baltimore, as well as of New York, Philadelphia, Washington and Richmond, on the wide belt of crystalline strata which follows the coast from Alabama to Maine and beyond. To this the name of "tide-water gneiss" has been applied, as forming the limit of tide-water in all the rivers of the Middle States.[2] It has been further shown in regard to our eastern streams that "the fall line along the inner margin of the Atlantic coastal plain of the United States is marked by important cities on nearly every large river that crosses it," viz., Trenton, Philadelphia, Richmond, Raleigh, Camden, Columbia and Augusta.[3]

But there is a coincidence of wider application, complexity and significance, in my opinion, in the belt of igneous occlusions near the Atlantic and its crossing at certain points by large rivers, with the location of cities along this coast.

At Manhattan Island it has been established that the violent folding of the schists and their extreme metamorphism are the self-evident and exclusive results of mountain-making at a period preceding the main Appalachian uplift. The necessary inference has been thus expressed: The ridges in neighborhood of New York City, "though in the form of low well-rounded hills, are as typical mountains, in a geographic sense, as are the peaks and ridges of the Green Mountains. The difference is merely that, in the vicissitudes of destruction, the former have been lowered nearly to a lowland condition. They are mountains reduced in elevation nearly to a sea level. If the rocks that once covered the site of the City of New York could be restored, they would rise into peaks rivalling the highest mountains in the world."[4] In the Piedmont plateau in Maryland the evidence of enormous denudation of overlying masses has led to the conclusion: "The region seems to represent the base-level of erosion of an old mountain-range that has been elevated perhaps the twentieth time, and is now again being eroded."[5]

[1] Williams, *loc. cit.*, 13.
[2] D. S. Martin, *Trans. N. Y. Acad. Sci.*, IV, 1885, 19.
[3] W. M. Davis, *Phys. Geog.*, 1898, 127.
[4] R. G. Tarr, *Bull. Am. Geog. Soc.*, XXIX, 1897, 29.
[5] W. M. Davis, *Bull. Geol. Soc. Am.*, II, 1891, 317.

The same twin belt of acid and basic crystalline eruptives, with their derivative schists, stretches from south to north along our entire Atlantic seaboard, approximately parallel to the coast but approaching tidewater only where it reaches Washington. Upon the granites and gneisses of its eastern margin, where this is crossed by the east-flowing rivers, a series of important cities and state capitals find their location : in Alabama, Montgomery, on the Alabama river ; in Georgia, Augusta, upon the Savannah ; in South Carolina, Columbia, upon the Congaree ; in North Carolina, Raleigh, upon the Neuse ; in Virginia, Richmond, upon the James ; in the District of Columbia, Washington, upon the Potomac.

Beyond that, directly upon the tract of eruptives, as elsewhere explained, there follow : in Delaware, Wilmington, upon Brandywine and Christiana creeks ; in Maryland, Baltimore, upon the Patapsco ; in Pennsylvania, Philadelphia, upon the Schuylkill ; in New Jersey, Jersey City and Hoboken, upon the Hudson ; in New York, New York City and Peekskill, upon the Hudson ; in Massachusetts, Boston, upon the Charles ; and in Canada, Montreal, upon the St. Lawrence. Throughout this great belt occur the same folding of beds and intense alteration of old sedimentary deposits as on Manhattan Island, and we find in all these sites of prominent American cities the degraded stumps of vast mountain ranges of the same ancient uplift.

The Coastal Chain of Volcanoes. — To the north of Washington, where this range stretched along the border of the inland sea, it has left unmistakable evidence as to important characteristics in structure and physiography not yet clearly set forth. The facts stated concerning the abundant intrusions on and near Manhattan Island mark this location as an ancient center of intense igneous activity at a very early geological period. It was probably contemporaneous with the one already recognized in the Cortlandt series, near Peekskill, on the south side of the Highlands of the Hudson.

In his discussion of the distribution of ancient volcanic rocks, as "disguised igneous masses in the oldest geological forma-

tions," along the eastern border of North America from Canada to Georgia, Williams has distinguished two parallel belts along the coast. In his accompanying map he has marked the Boston basin as the known location of one such volcanic center in the more eastern belt; he also included, as another probable location, the region near Peekskill, nothwithstanding the absence there of any recognized effusive or volcanic eruptives. This was based on the following view: "In New York State there are, as far as the writer is aware, no remains of igneous rock which have solidified at the surface. Nevertheless the isolated and highly differentiated Cortlandt series, near Peekskill, presents us with the deeply eroded roots of an ancient volcano, probably of Cambrian or Silurian age, whose superficial parts have entirely disappeared. The elæolite-syenite area in northern New Jersey is probably of the same character."[1]

Though on the same map no such designation has been made of the sites of New York, Philadelphia and Baltimore, the correlation which I think has been demonstrated, by data already given, would connect also the igneous rocks of these tracts, with their characteristic differentiation — gabbros and diorites, pyroxenites and serpentinoids, granites and pegmatites — rather with those of "the basal portions of volcanoes" than with abyssal types. Each of these three places, as well, offers in the disposal and structure of the igneous masses, the same evidences of local concentration of igneous activity, to claim a position on the same ancient volcanic belt.

In the tract from Maryland to Georgia, also, where the lesser intensity of metamorphism has favored escape from effacement, recent investigations have even proven the presence of volcanic effusives, in the form of metarhyolite, diabase, gabbro and their derivatives.

Mount Manhattan and its Associated Peaks. — If then we are to look upon the acid and basic intrusions, now found crowding the schists of Manhattan Island, as but the lower portions of vents which reached the surface in the form of fluent lavas, we are dwelling, at this site, not merely upon the igneous injections

[1] G. H. Williams, *Jour. Geol.*, II, 1894, 1–31.

which commonly swarm along the axis of extensive orogenic movement, but probably over the roots of one of the oldest and most violent volcanic craters ever existent upon the earth.

In previous discussions of the eruptive crystallines along the eastern border of the Appalachian belt, grounds have been presented in favor of a prevalent hypothesis of the elevation of a mountain range upon the western rim of an Archæan continent along the Atlantic, to which the name "Appalachia" has been applied.[1] However, in view of the probable relegation of these crystallines to Palæozoic age, it has been recently urged that "the location of this hypothetical range, which is supposed to have supplied the sediments for the Appalachian sea during Palæozoic time, must be shifted, at least for the earlier Palæozoic, farther east where its roots would not lie buried under Coastal Plain deposits."[2] Nevertheless the evidences of a huge mountain range along the tract of these Palæozoic crystallines remain exactly the same, testifying, it would appear, toward the succession of that Archæan range by another enormous uplift along this inner line, in advance of the main Appalachian uplift on a line still further west. Its period, if estimated by that of the igneous activity, fell probably, it is believed, in the earlier part of the interval between early Silurian and late Carboniferous.

From local evidences of intense vulcanism there is further reason to believe that this range rose here and there into lofty peaks. For the purpose of the physiographer, the one on the site of New York City may be designated as *Mount Manhattan*. Some comprehension of its height and dimensions may be gained, not merely from allowance for its apparently vast contribution of secondary débris to the later Palæozoic and Mesozoic within the interior sea-basin, but from an estimate of the area apparently covered by its base. To the north, rocks of exactly the same character stretch for forty miles till they blend with the Cortlandt series at the Archæan Highlands on the Hudson river. To the northeast, they extend over Westchester county and beyond into Connecticut. To the east, on the shore of Long

[1] B. Willis, *Nat. Geog. Mag.*

[2] E. B. Mathews, *loc. cit.*, 159.

Island, a remnant of the same rocks survives, penetrated by the same intrusive sheets of pegmatite and diorite, and they may underlie the island beyond. To the south, the submarine course of the buried channel of the Hudson river reaches for 120 miles, with a topographical uniformity which suggests erosion of the same class of rocks in that direction. On the southwest and west, the same gneisses, amphibole schists, serpentine and granite outcrop along the shore for over ten miles, on a probable westward extension of the same formation into or across New Jersey. The eruptive tract on Manhattan Island thus forms the center of a vast region of sharply folded, crystalline schists, now degraded toward a base level, whose area, largely that of the base of Mount Manhattan, stretches over hundreds of square miles.

The survival of the remaining portion of these ancient schists above the sea-level has been due only in part to the highly tilted position of the layers, offering but their edges to attack by agencies of erosion and decay. Almost every knoll upon the island and even the long ridges, reaching 150 to 200 feet in altitude, such as Morningside Heights, Washington Heights, and the heights of Inwood, are capped or seamed by sheets of igneous intrusions of both classes, or even so saturated with pegmatite lenses as to have become consolidated into a granite mass. The resistance and protection thus afforded to the surrounding schists are attested by these hard bands and rounded hummocks, gnawed and scored by the teeth of the Great Glacier, and have preserved the varied topography of this exposed rocky promontory in preparation for the beautiful site of the great city.

But the peak of Manhattan was but one of many which crowned the mountain wall stretching from southwest to northeast along the old coast, and which call for designation, for convenient reference.

The lofty crest, with volcanic vent, on the site of Wilmington, Delaware, may be indicated by the original Indian name of that locality,[1] as *Mount Hopokahacking*.

[1] I. Acrelius, A History of New Sweden, Philadelphia, 1874, 24.

For the peak near Baltimore, Maryland, the name of the village which stands near the center of the eruptive tract may be used as *Mount Powhatan.*

The summit which rose over the site of Philadelphia, Pennsylvania, may be distinguished, after the old name of the Passagonke Indians, as *Mount Kuéquenáku.*[1]

The old volcano whose agency, according to Williams, is indicated by the eruptive rocks of the Cortlandt series near Peekskill and Stony Point, on opposite sides of the Hudson River, may be referred to, after the name applied to that locality by the Mohegan Indians, as *Mount Sachoes.*[2]

To the northeast, for the center of volcanic activity at the Boston basin, we may resort to the old Indian name, in the form of *Mount Shaumet.*[3] A variation of this name, Shawmut, has been already applied to one group of eruptives in vicinity of the same city.[4]

Still further to the north, but inland, at the head of tidewater on the river St. Lawrence, the volcanic intrusions on the site of Montreal indicate an eruptive center at another peak, which may be designated, after the Algonquin name of the Indian village at that place, as *Mount Hochelaga.*[5]

The explanation of this interesting relationship, the location of many of the most important cities of our eastern seaboard almost in a straight line over the ruins of these ancient volcanoes, rests primarily upon local hardening effected in the prevalent folded gneisses, seamed and saturated by tough igneous rocks, particularly those of acid constitution ; secondarily, upon variation in resistance, afforded by difference in structure

[1] Signifying "the grove of the long pine trees," according to Heckewelder, S. G. Drake, Book of the Indians of North America, Book II, Boston, 1834, 17. For this and some of the other local names I am indebted to a painstaking search by Principal John W. Davis, Bedford Park, Bronx, New York City, Recording Secretary of the New York Society of Pedagogy.

[2] R. Bolton, Hist. of Westchester Co., I, New York, 1884, 112.

[3] J. Quincy, A Municipal History of the Town and City of Boston during Two Centuries, 1630–1830 ; E. M. Bacon, Boston, a Guide Book.

[4] W. O. Crosby, *Tech. Quart. Boston*, xii, 1899, 13, 163.

[5] Hochelaga Depicta ; the early history and present state of the City and Island of Montreal. N. Bosworth, Montreal, 1839, 19, 30.

and materials, to subsequent erosion during base-levelling and to direct attack of crossing streams. The latter characteristic — topographic modification through the presence of intermixed eruptives or of hard and soft derivative schists — has afforded conditions most favorable for the establishment of a large city. In the beginning, convenient access to both river and sea, with abundance of sea-food, has been as attractive to the aborigines who first chose, occupied and named these sites, as to the civilized settlers who followed. Then the excellence of a deep soil, rich in lime and alkalies, derived from decay of the occluded lavas and traps and from their glacial attrition, has offered an important condition to the agriculture of the primitive inhabitants and afterward of the earlier immigrant. But the main advantages for permanent human settlement have been gained through the deep erosive dissection of a rock stratum of varied constitution. A glimpse from a high point, near almost any of these cities, reveals the essential attractions in depth of water along bold shores, capacious harbor, convenience and varied beauty of building sites, and access to outcrops of building stone, clay and sand, which have resulted directly from the diversified topography but initially from its volcanic foundations.

PLATE V.

PLATE V.

Map of tract along Spuyten Duyvil Creek, at extreme northern end of Manhattan Island. The dark broken band indicates the outcrops of the layer of dioritic schist. The figures show the strike and dip as observed in the outcrops of the schist and gneisses. The dotted line at 216th Street represents the position of the cross-section shown in Plate VI.

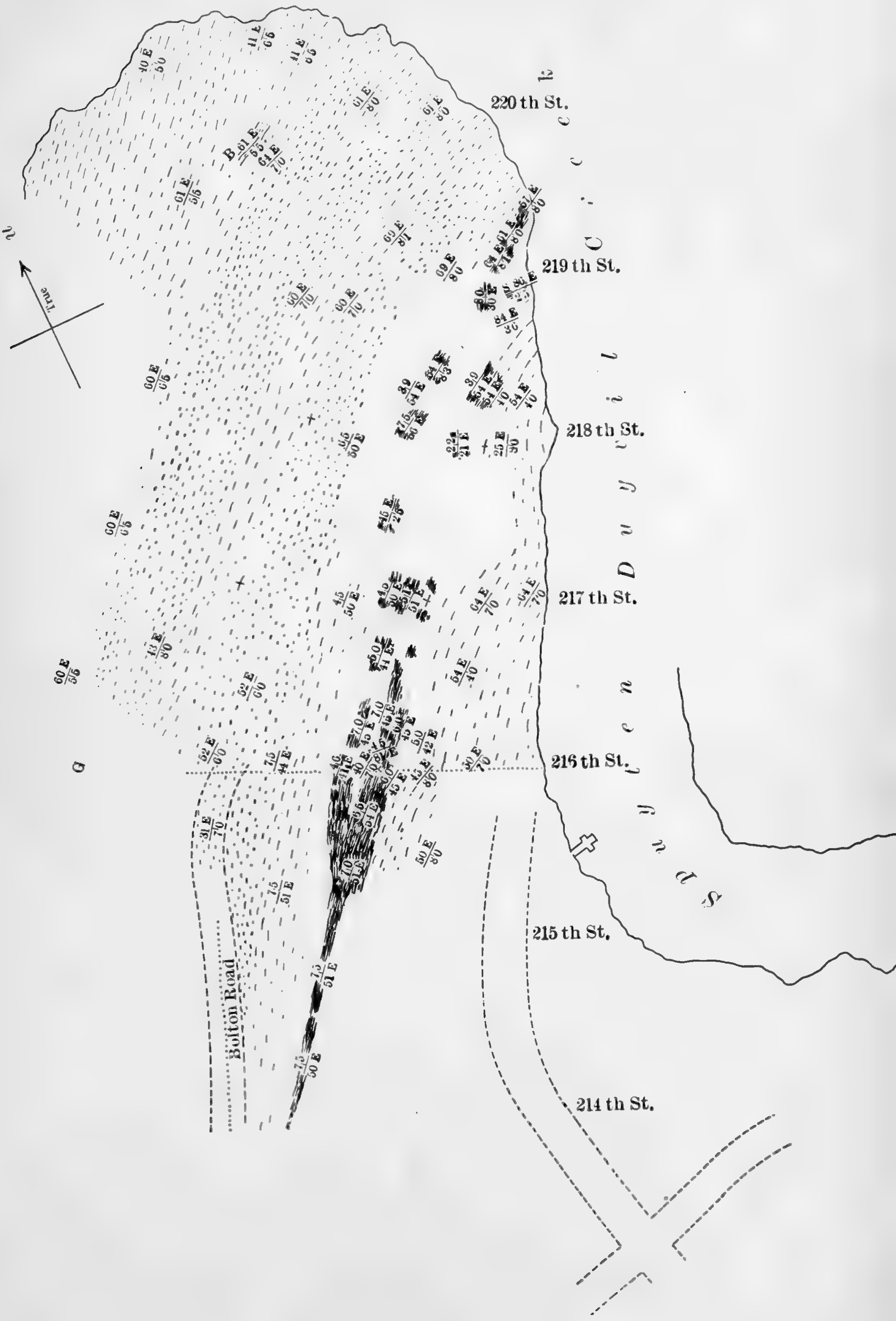
Hudson River
Spuyten Duyvil Creek
220 th St.
219 th St.
218 th St.
217 th St.
216 th St.
215 th St.
214 th St.
Bolton Road
True

PLATE VI.

PLATE VI.

Cross-section of beds on slope from Spuyten Duyvil Creek up to crest of Inwood Ridge. The dark layer of dioritic schist, displaying two anticlinal folds, is intercalated in micaceous gneiss. Toward the crest the lowest bed of pegmatitic gneiss is indicated by the broken lines.


70
80
60
70
70
46
75
70
60

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ADAPTIVE MODIFICATIONS OF THE LIMB SKELETON IN AQUATIC REPTILES AND MAMMALS.

BY RAYMOND C. OSBURN.

The history of animal life reveals the fact that a number of widely separated groups of reptiles and mammals have taken up aquatic life. That these aquatic animals were derived from terrestrial forms is now universally conceded. Some of these forms seem to have attained almost to perfection in their adaptation to life in the water, but the great majority are found scattered all the way along the path by which the former progressed. The terrestrial type of limb, with which at the beginning all these forms were endowed, is not well fitted for use in the water, either for propulsion or for balancing, hence a great change in the limb is necessary before its possessor can become perfectly at home in its new environment. This change affects the limb throughout and finally brings about a complete reorganization of the limb in which scarcely any of the original elements can be recognized. Thus in later Ichthyosaurs the only element of the original limb which could be identified with certainty if removed from the limb, is the propodial, which by virtue of its position at the junction of the limb with the girdle, has retained somewhat the appearance of a propodial bone. While, at the beginning, there must necessarily have been differences in size, shape and arrangement, and even in the number of bones present in the animals belonging to groups of such widely different ancestry as these here dealt with, yet in the attempt to produce a perfect swimming organ the amount of parallelism exhibited is remarkable.

In most cases it is safe to say that the limbs were at first used both as organs of propulsion and of equilibration, and, indeed, certain groups have never passed this condition (Chelonia, Plesiosauria and Pinnipedia), though it is quite possible that

some of the long-tailed reptiles like the Mosasaurs may have used the tail for propulsion from the very beginning of their aquatic existence, as the newts and certain semi-aquatic lizards are known to do. The tail is a much more efficient organ of propulsion than the limbs, however, and in forms where the anatomical difficulties in the way are not too great a tail fin is developed which relieves the limbs of the greater part of their work and leaves them with only the function of equilibration to perform. This results in the reduction in size of the fore limbs and the degeneration or loss of the hind limbs in the most advanced forms. The final result, then, is as near an approach as possible to fish-like conditions of locomotion, with an expanded tail fin for a propeller and thin, flexible paddles on the sides for balancing.

Naturally, the forms which show the greatest adaptation to aquatic life are those such as the Cetacea and Ichthyosauria which have entirely given up their land relations, while those which come upon the land occasionally, as the Chelonia and Pinnipedia at the breeding season, retain of necessity certain characters of the terrestrial type of limb. In the present paper the groups to be considered are those whose adaptation has progressed to the extent of modifying the limb skeleton, especially the Cetacea, Sirenia, Ichthosauria, Plesiosauria, Mosasauria and Thalattosuchia, and the less modified Pinnipedia and Chelonia.

In the limbs of these forms the following modifications seem to be the most usual and of the greatest importance in the change from the terrestrial to the natatory type of limb:

1. Abbreviation of the limb as a whole.
2. Curvature or backward extension of the limb.
3. Distal dilatation of the limb.
4. Parallelism or convergence of the fore and hind limbs.
5. Tendency toward loss of hind limbs.
6. Tendency toward similarity in shape and function of all the bones of the limb.
7. Elongation of digits.
8. Hyperphalangy, or increase beyond the normal number of phalanges.

9. Hyperdactyly, or increase beyond the normal number of digits.
10. Formation of smaller skeletal parts.
11. Concentration of all parts except the digits.
12. Cartilaginous progression in joints.
13. Loss of movable articulations in the limb.
14. Loss of tuberosities for muscle attachment.

Bearing in mind now the fact that the various forms have been derived from different sources, and the possibility that in the process of their adaptation to aquatic life they may not all have followed exactly the same course because of special environments or of innate differences in potentiality for modification, let us proceed to examine the above points as they are represented in the various groups of animals.

Abbreviation of the Limb.

In all the forms of animals under consideration that have progressed far enough in aquatic adaptation to lose their land relation there is noticeable a very great shortening up of the limb as a whole. So far is this process carried in the Cetacea, Ichthyosauria and Mosasauria that the total length of the limb in many cases may be greatly exceeded by the diameter of the body. Especially is the abbreviation marked in those forms which have the tail fin well developed, as the Cetacea and Sirenia in which the hind limb is lost entirely, and in Ichthyosaurs some of which have the hind limb very much reduced. The shortening always begins in the proximal end of the limb, with the propodial and epipodial elements, and the digits are not shortened until actual degeneration sets in. This question will be given further mention in certain of the following topics.

Curvature or Backward Extension of the Limbs.

Almost without exception the natatory limb is curved backward. This may be seen in the Cetacea and Pinnipedia among the Mammals and in the Plesiosauria and Thalottosuchia and most Ichthyosaurs and Mosasaurs as well as in the marine Chelonia, among Reptiles. The extreme of curvature is found

in the hand of the Thalottosuchian *Geosaurus* and the Cetacean *Globiocephalus*, in which the extremities of the fingers are at a right angle with the long axis of the humerus. The opposite condition is found in some of the Ichthyosaurs and Mosasaurs in which the limb is quite straight to the ends of the digits, but in such cases the whole limb is directed backward from the articulation with the girdle sufficiently to compensate for the lack of curvature. It must be noted, however, that in both these groups the most specialized forms show the backward curvature as well as the average of the curved-limb forms (cf. *Ichthyosaurus quadriscissus* and *Baptanodon natans* among the Ichthyosaurs and *Tylosaurus* among the Mosasaurs). Generally speaking, the longer limbs are more curved but this is not without many exceptions. The hand of *Geosaurus* is at once the shortest and most curved that has been noted, while some of the long limbed Ichthyosaurs, *e. g.*, *I. acutirostris*, have the limb quite straight. The backward curvature of the limb may be attained in a number of ways in various forms, by one of the following modifications, or, more frequently, by a combination of several of them in the same limb.

Curved Bones of the Limb. — This is exemplified in all the groups where the bones of the limb have not become so shortened as to obscure any curvature. In the Cetacea it is shown by numerous forms to a greater or less extent. The humerus is generally too short to exhibit any curvature but the radius and ulna are distinctly curved in a number of forms (cf. especially *Balænoptera*). The Ichthyosaurian limb is too much shortened to show curvature in any single bone, except that in *Mixosaurus*, the most primitive of the group, the humerus is long enough to show a distinct curve. The longer limbed Plesiosaurs, as a rule, show the curved humerus and femur to a greater or less extent (cf. *Plesiosaurus*, *Cimoliosaurus*, *Peloneustes*, *Dolichorhynchops*, etc.). In the Thalattosuchia the humerus is very greatly shortened but the longer femur is very noticeably curved. The Mosasaurs, as a rule, do not exhibit any curvature of the bones, which are greatly shortened, but in *Tylosaurus* the humerus is considerably curved. The Pinnipedia

and marine Chelonia still retain their land connection to some extent so their limbs are less modified than in the other groups, but even here the radius and ulna and corresponding elements of the hind limbs are in some forms very distinctly curved. The other bones of the limbs are naturally too short to show any curving, except very occasionally, *e. g.*, the first metacarpal of *Geosaurus*.

In some cases where the humerus and femur are not noticeably curved the anterior border is longer than the posterior and as a result the distal articular surface is set at an angle to the long axis of the bone. The result is the same as that produced by the curving of the bones. Examples of this angulation of the joint may be seen in all the groups, but it is by no means constant and only about half of the forms examined show it, the others being indifferent or actually angulated in the reverse direction. However, any forward angulation of the joint is always more than compensated for by some other means, usually by having the radius longer than the ulna, etc. (cf. *Cimoliosaurus eurymerus* or *Mixosaurus*).

The Greater Length of the Radius and Tibia as Compared with the Ulna and Fibula. — This condition results in a backward angulation at the distal extremities of these bones very much as in the longer anterior border in the humerus or femur. It is, however, found in a much larger proportion of the forms studied. The measurements were taken from the middle of the articulating surfaces as in some cases the outline of the bones is very irregular. All of the Cetacea, as far as I have examined them, have the radius at least a little longer than the ulna and in some forms, *e. g.*, *Phocæna*, it is very noticeably so. In the majority of the reptilian forms studied the radius was found to be longer than the ulna; in some cases they are of equal length, but none were found in which the ulna exceeded the radius. In the hind limb the same results were obtained except that in *Geosaurus* the fibula is somewhat longer than the tibia. It does not necessarily follow from the above that an angulation of the limb is always produced by the longer radius or tibia. In some cases the effect is very noticeable and in at least one

case, *Cimoliosaurus eurymerus*, the curvature of the limb is produced entirely in this region, the radius being fully twice as long as the ulna, but in most reptilian forms the greater length of the anterior bone only compensates for other conditions. In the *Mosasaurs* the carpus and tarsus after the manner of their Lacertilian progenitors, are much wider posteriorly, especially among the less modified members of the group, and the longer radius and tibia help to some extent to even up this deficiency in the anterior part of the limb. In the hand of *Mixosaurus*, again, the longer radius compensates for the humerus, which is shorter on the anterior border than on the posterior.

Suppression of Carpus and Tarsus Toward the Posterior Side.— In a few forms this is sufficient to cause a very distinct curve or angulation in this region of the limb. In *Delphinapterus*, *Globiocephalus* and *Geosaurus* the carpus is quite wedge-shaped with the point posterior. In *Delphinapterus* this wedge is also curved. In the Ichthyosaurs and Plesiosaurs the carpals and tarsals are so similar to the bones of the digits that in many cases it is impossible to distinguish between them with any certainty. In *Plesiosaurus dolichodeirus*, however, the fifth digit is seen to articulate higher up than the others, and in the very advanced forms, such as *Cimoliosaurus* among the Plesiosaurs, and *Baptanodon* and *Ophthalmosaurus* among the Ichthyosaurs, where the pisiform (cf. Baur) has moved up alongside of the epipodials to articulate with the humerus. This shifting of the bones brings the digits on the posterior side of the paddle to articulate higher up than the anterior ones, thus assisting in the curvature of this part of the limb. In the Mososaurs as a group, the carpals and tarsals are lacking or nearly so at the anterior border but very well developed at the posterior side, a condition inherited from their Lacertilian ancestors, according to Williston. But while the less specialized Mosasaurs all show this condition it is very interesting to note that in more modified forms, such as *Tylosaurus*, the carpals and tarsals are almost wanting on the posterior side and the fifth digit approaches articulation with the ulna.

Curvature of the Digits. — This condition exists quite gener-

ally and occurs in all groups. In a few forms, by way of exception, the digits are quite straight but in every case these forms seem to be earlier and less adapted to aquatic life, and in every group where straight digits occur it is worthy of note that the species occurring later have the digits curved. Occasionally the limb may be sufficiently curved in some other region, when the digits will be more nearly straight (cf. *Cimoliosaurus eurymerus*). The Cetacea, without exception so far as my observations have carried, have the fingers more or less curved. Sometimes, as in *Balæna* and *Balænoptera* the curvature may be slight, while in others, *e. g.*, *Globiocephalus*, the curvature is very great. The Plesiosaurs, also, seem to have the digits curved in all cases. In *Cimoliosaurus eurymerus* the curvature is but little; in *Plesiosaurus dolichodeirus* it reaches the other extreme. The Thalattosuchia (cf. *Geosaurus*) show the backward curvature, also. In the Mosasaurs, *M. lemoinieri* seems to have the digits of the hinder limb perfectly straight, and the hand of *Clidastes velox* is little, if at all, curved. It is worthy of note here, however, that these forms also show a more primitive condition of carpus and tarsus and other indications of lesser adaptation to aquatic life than is found in *Platecarpus* and *Tylosaurus*, for example, which have the digits well curved. The Ichthyosaurs present a variety of conditions. The Triassic *Mixosaurus*, which is undoubtedly the most primitive, has the digits distinctly curved. Some of the later Jurassic forms, such as *Ichthyosaurus acutirostris* and *I. communis* have the digits quite straight and these species are much more modified in some respects than *Mixosaurus*. However, against this must be placed the fact that in *I. quadriscissus*, *I. ingens* and *Baptanodon natans*, which by cartilaginous separation of the bones and by other signs point to a greater adaptation to a swimming life, have the digits curved. Again the Triassic genera *Merriamia* (*Leptocheirus*) and *Toretocnemus* which Merriam has recently described and which are nearly if not quite as old as *Mixosaurus*, have the limbs fully as primitive as that genus in some respects and greatly modified in others. In *Merriamia* the digits are somewhat curved, but in *Toretocnemus* they seem, judging from somewhat fragmental

remains, to be quite straight. Possibly the very great reduction in size of the limbs of the latter genus may be responsible for this condition.

Frequently the paddle is extended backward by the separation of the digits at their distal extremities so that the posterior digits are thrown back at an angle to the others instead of being parallel or nearly so. This is never found in the anterior border of the paddle, but when present is always posterior. Many of the Cetacea, such as *Phocæna*, *Monodon*, *Delphinapterus*, *Globiocephalus*, *Balæna*, etc., exhibit this to a remarkable degree. In the Mosasauria the angle at which the fifth digit is set is remarkable, especially in the very short limbed *Clidastes velox* and in *Platecarpus*. Other forms may show this to a less extent and the third and fourth digits may also be somewhat separated. The Thalattosuchia show but little separation of the digits and in Plesiosauria and Ichthyosauria the digits are remarkably close together. Again it must be remarked that in *Baptanodon*, the latest of the Ichthyosaurs, there is some separation of the digits.

Another factor which sometimes enters to cause a backward extension of the limb is hyperdactyly, or the addition of extra digits on the posterior side of the limb. According to Baur this addition of extra digits never occurs on the anterior border. In the Cetacea very rarely a sixth digit, or part of one, is added. In Ichthyosaurs it is quite common and as many as four extra digits have been noted in the hand of *I. longimanus*. Hyperdactyly does not appear in any of the other groups.

The greater length of the digits toward the posterior border as compared with the anterior ones causes a sloping off toward the posterior border that gives much the same effect as the curving of the digits, with which it is almost always coupled. In almost all cases the first digit is noticeably shorter than those following and in many cases the second and even the third may be somewhat abbreviated so that a graduated slope is formed from the first to the fourth. In the few cases where the first digit is equal to or greater than those following, as in the foot of *Mixosaurus* and the hand of *Ichthyosaurus ingens* or *I. conybeari*, the digits are greatly curved. However, the hind

paddle of *Mosasaurus lemoinieri*, though in part wanting, and of *Ichthyosaurus acutirostris*, also lacking the tips of the digits, seem to be exceptions even to this and have the first digit as long as the others and perfectly straight. Perhaps a complete limb might show this to be an error in judgment, however. Frequently in the Cetacea the first digit is so reduced as to be nearly or entirely wanting, and in the longipinnate Ichthyosaurs it seems to be absent in all cases. This results naturally in throwing the anterior border of the hand on the second finger, and thus farther back.

In a few instances the paddle is extended backward largely by the broadening of the bones. Examples of this may be seen in *Mixosaurus*, *Cimoliosaurus*, etc. This matter will be alluded to further under the head of distal dilatation.

Distal Dilatation.

A modification of universal occurrence among swimming animals is the distal dilatation or broadening of the limbs in the formation of paddles. At any rate the limb becomes broad in proportion to its thickness. In certain long-limbed forms like *Megaptera* among the whales or *Ichthyosaurus acutirostris* among the reptiles the limb is evidently not greatly broadened, but it is at least reduced in thickness until a thin paddle-like form is attained. The incipient stages of this dilatation may be seen in animals which have only recently taken up aquatic life and which have not yet lost their land-relation. Evidently the first part of the limb to show this broadening is the most exposed part, *i. e.*, the hand or foot. Later the process continues up the limb until finally all the bones of the limb may become affected. The humerus and femur may even become involved in this change clear up to the articulation.

In all but a few cases the point of greatest breadth remains in the digits. The most common method of increasing the breadth of this region is found in the spreading of the digits. This is shown by practically all aquatic mammals and by aquatic reptiles generally except the Plesiosaurs and the Ichthyosaurs where spreading of the digits is rare and slight. Again, the breadth

of the bones of the digits may be increased sufficiently to make this portion of the limb the widest. In the Sirenia the width of the hand is in part due to this, and in Plesiosaurs where the hand is widened and in some Ichthyosaurs the width is entirely due to the great breadth of the digits. In many Ichthyosaurs and rarely in the whales the hand or foot may be widened by the addition of one or more extra digits, a process known as hyperdactyly. Kükenthal has shown this to come about in *Beluga*, the white whale, as the result of the splitting of the fifth digit and there is reason in the view that hyperdactyly has come about in the same way in Ichthyosaurs. In Cetaceans never more than one extra digit is formed, but as many as four extra digits, or nine in all, are known in Ichthyosaurs. These without exception are found on the posterior border of the paddle. It is possible that still another method of broadening the hand may have been the separation of the bones of the digits by embedding in cartilage. In *Ichthyosaurus ingens*, and especially in *Baptanodon*, this seems true.

In a few cases only, the carpal and tarsal region is found to be the widest part of the limb, though this region is usually somewhat broadened. In *Mixosaurus* this is exceptionally well shown. In some whales as *Globiocephalus* or *Phocæna* this region is the widest part of the limb but here the fifth finger has moved up alongside of the carpus, and the carpus itself is not greatly broadened. In some instances the breadth of this region appears to be much increased by the cartilaginous separation of the bones. Thus in *Delphinapterus*, *Phocæna*, etc., the carpal region is quite broad while the bones are small and embedded in cartilage. The same thing is evident in *Baptanodon* among the Ichthyosaurs. A cartilaginous extension of the posterior border of the carpus, materially widening this region, is known among the Cetacea.

The epipodials tend toward great breadth and become shortened about in proportion as they become widened. Among the forms here dealt with they are found the least modified in the genus *Balænoptera*, among the Cetacea, where, although they are somewhat flattened, they are about twice the length of

the short humerus. Even in the Sirenia there is considerable broadening in this region. Among the reptilian groups the epipodials are greatly modified in every case examined, except in the hind limb of Thalattosuchia. In a number of cases the greatest breadth of the limb is found in this portion. In Plesiosaurs this seems especially to be true. In *Cimoliosaurus trochanterus* and *C. portlandicus* the position of the "pisiform" alongside of the ulna and its homologue beside the fibula makes this region very evidently the widest. In the hand of the Thalattosuchian *Geosaurus* the breadth is greatest in this part, due to the extreme breadth of the very short radius and ulna. In Mosasaurs also these bones are very broad, and in every case in Ichthyosaurs they are much broadened though this region is usually not as broad as the more distal portion of the limb.

There are two factors producing the breadth in the epipodial region, the increase in the breadth of the bones themselves, and the separation of the bones at their distal ends. In the Mammalia there is no real separation of the distal ends of the radius and ulna though in some cases (cf. *Globiocephalus*) the intermedium interlocks between their ends. In Plesiosauria and Thalattosuchia also no distal separation is evident, and in Ichthyosaurs it is seen only in *Mixosaurus* where it is quite noticeable and is probably a primitive character. In the Mosasaurs, however, they may be separated at a very wide angle (cf. especially the hands of *Clidastes* and *Platecarpus*) and all show it to a greater or less extent. It is possible that this tendency has been derived directly from their Lacertilian ancestors which show some distal separation, but, however its presence is to be accounted for, it seems pretty certain that the Mosasaurs have developed it greatly and made the most of its possibilities in broadening the paddle. *Stereosternum*, one of the Rhynchocephalia, shows quite a little distal separation of the epipodials. It also has the fifth digit set out at an angle as in the Mosasaurs.

The humerus and the femur are probably the last bones of the limb to become affected by distal dilatation, but in the most

advanced cases they may be broadened almost to the point of the articulation with the girdle. The only completely aquatic forms which show no modification of the humerus in this way, as far as I know, are the Sirenia. This lack of modification may be accounted for by the peculiar way in which the paddles are used by these animals when feeding or resting in shallow water and in holding the young. The femur of *Geosaurus* shows little or no dilatation and remains very long, though in absence of tuberosities, in curvature and in other ways it is evidently natatory. The humerus of *Geosaurus* is much more progressive and is greatly shortened and broadened. In the Cetacea without exception the greatly shortened humerus is also noticeably widened, especially in *Phocæna* and *Globiocephalus.* In the Plesiosaurs the humerus and femur are longer than is usual among aquatic forms, but the dilatation is very evident. In *Cimoliosaurus trochanterus* and *C. portlandicus* the "pisiform" and its homolog of the hind limb find room to articulate with the propodial beside the greatly widened epipodials, and *C. eurymerus* is even more expanded than these, being the only case, as far as observed, where the broadest part of the paddle is the distal end of the humerus. The extreme of modification is found among the Mosasaurs and Ichthyosaurs. In the former it is always marked and reaches a climax in the hand of *Platecarpus*, *Plioplatecarpus* and *Clidastes.* According to Williston the humerus of *Platecarpus* is the most modified, its width distally being nearly equal to its length. The Ichthyosaurs are equally modified, even in the early Triassic forms (cf. *Mixosaurus*, *Toretocnemus*, *Merriamia* and *Shastasaurus*). The humerus of *Shastasaurus*, according to Merriam, is the most specialized known — "the shortest propodial segment known in the limb of an Ichthyopterygian" — and a very narrow notch on the anterior border represents the "last trace of a shaft of a 'long bone.'"

In the marine Chelonia there is formed a very good paddle and the distal dilatation of the whole limb is very evident. The individual bones do not show it to any extent, however, as far as observed. The seals are in the same condition, and the

partial retention of terrestrial habits probably accounts for both. The Nothosauridæ, probable ancestors of the Plesiosaurs, while undoubtedly aquatic, had not necessarily — judging from the condition of the limbs — lost their land connection, and they show but little distal dilatation of the bones. *Lariosaurus* has the humerus well curved and somewhat expanded distally, and *Simosaurus*, according to the plates in Von Meyer's "Fauna der Vorwelt," shows considerable distal enlargement. If the Nothosauridæ are the ancestors of the Plesiosauridæ, as seems to be the case, we have in these two families the most complete story of the evolution of the swimming limb known in any one group, for the earliest Triassic members of the Nothosauridæ are semiaquatic while the latest Cretaceous forms of the Plesiosauridæ are thoroughly adapted for marine life as von Zittel has already pointed out (1902, p. 172).

Parallelism of Fore and Hind Limbs.

In many aquatic forms there is a very evident parallelism between the fore and hind limbs, and a correspondence in action which is never met with in terrestrial forms. The fore and hind limbs in most cases meet the water in the same manner with the result that they become very similiar in structure. The Pinnipedia are an exception, for, while both fore and hind limbs are evidently adapted to aquatic life, there is a very different use made of them in swimming. Cetacea offer no evidence on either side as the limbs of ancestral forms are not known and recent forms lack the posterior limbs. A comparison of the fore and hind limbs in Ichthyosauria, Plesiosauria or Mosasauria, however, shows great similarity in shape and structure as well as in their angle of attachment with the body. There can be no question but that the fore and hind paddle of a Plesiosaur acted in the same manner in propelling the body through the water. In Mosasaurs the same thing is evident. In later Ichthyosaurs, owing to the development of the tail fin, the hind limb becomes much reduced, but still it retains its similarity to the fore limb (cf. *Ichthyosaurus communis, I. Quadriscissus* etc.), while in *Mixosaurus*, which is the least modified

of the Ichthyosaurs, the simility in shape, size and angle of attachment is easily noted. The Thalattosuchia have the limbs so greatly different in length that it is difficult to find much similarity except in the matter of curvature and angle of attachment.

It is to be noted that in the matter of curvature or backward extension the limbs are always similiar — if the fore limb is straight the hind limb is also found to be straight, but if the fore limb is curved the hind limb will assume about the same degree of curvature. (Cf. *Mixosaurus*, *Toretocnemus*, *Platecarpus*, *Tylosaurus*, *Plesiosaurus*, *Dolichorynchops*, etc.).

The Tendency Toward the Loss of the Hind Limbs.

This character in those forms which have developed a caudal fin is found almost without exception. In such forms the tail becomes a much more efficient propelling organ than the limbs and the latter are of use chiefly as organs of equilibration. The anterior limbs, from their position, are naturally more useful in this respect than the posterior and the latter tend toward reduction. In aquatic animals which have not developed a tail fin we have two widely different conditions. The Pinnipedia illustrate one condition where the hind limbs swing backward and together act as a propeller very much after the fashion of the flukes of a whale — so much so in fact, as to have suggested to Ryder the mistaken hypothesis that the flukes of the Cetacean are only misplaced and modified hind limbs. The long and supple vertebral column renders this motion possible in the Pinnipedia. In the Chelonia the nature of the spinal column and the box-like exoskeleton prevent any such use of the hind legs as is seen in the seals, and the fore legs become greatly enlarged organs of propulsion while the hind paddles are comparatively very weak. The skeleton of *Thalassochelys*, for example, reminds one of a side-wheel steamboat with enormously large paddles and with twin rudders behind.

Among the forms with a tail fin the Cetacea and Sirenia are preëminent with the entire loss of a posterior limb externally. The Ichthyosauria at first seem a little puzzling from the fact

that the earliest forms known, *Mixosaurus* from the Middle Triassic of Lombardy and *Shastasaurus*, *Merriamia* and *Toretocnemus*, from the Upper Triassic of California and Nevada, offer very conflicting evidence. One would naturally expect the limbs of these early aquatic forms to show to some extent the characters of their terrestrial ancestors — at least to approach this character more nearly than later forms—and this, indeed, *Mixosaurus* does, as Baur has shown (Ueber die Abstammung der amnioten Wirbelthiere). In this genus the hind limb is as well developed as the anterior and both bear very evident marks of terrestrial origin. With the other Triassic genera mentioned, however, the case is quite different. In all three the limbs are very much specialized and much reduced, but in *Toretocnemus* the hind limb is equal to or greater than the fore limb, according to Merriam, while in *Merriamia* the hind limb appears quite diminutive in comparison with the fore limb. When our knowledge of these genera is more complete we shall doubtless find them to be an early offshoot of primitive Ichthyosaurs, in which the limbs have become precociously adapted to aquatic life. The tail of *Delphinosaurus* (*Shastasaurus*) *perrini*, according to Merriam must have borne a very well developed tail fin, as it shows the sharp deflexion and elongated spines found in later Ichthyosaurs. The Ichthyosauridæ, of the Jura-Cretaceous, have the anterior limb much better developed than the posterior one, and sometimes the latter is very weak. In these forms the tail fin was well developed for locomotion. (See Fraas's figure of *I. quadriscissus*, Quenst.)

The Plesiosaurs are comparatively long-legged and short-tailed and the limbs were undoubtedly used for propulsion to a greater extent than in those forms with a longer tail. While the limbs are evidently adapted for swimming they never become so reduced as in forms which come to use the paddles mostly for purposes of equilibration. Williston has well expressed the condition in this group, "Among the Plesiosaurs the hind limbs are always powerful and well developed, though in all forms known to me they are less powerful than the front ones. Here the relative shortness of the tail has imposed a distinct propelling or sculling function upon the limbs."

The most highly adapted Mosasaurs possessed a tail fin produced by the elongation of the neural and hæmal spines and while this was probably not as effective a propelling organ as the more highly specialized flukes of the whales and Ichthyosaurs, yet its presence was sufficient to cause a reduction in the hind limbs. Williston has already remarked upon this evident "weakening of the hind limbs, particularly in the more specialized groups like the Tylosaurinæ." In *Clidastes velox* the hind limbs seem much weaker than the anterior ones.

The Thalattosuchia seem to be an exception to the rule, for according to Fraas, *Geosaurus suevicus*, the only thoroughly known form of the group, has the paradoxical combination of a well developed tail fin and a hind limb very much larger than the fore limb. The fact that this limb shows only comparatively little adaptation to aquatic life suggests the possibility that *Geosaurus* had only recently lost its land relation, the well developed tail fin notwithstanding.

Tendency Toward Similarity in Shape and Function of all the Bones of the Limb.

In the limbs of swimming animals there is no occasion for the specialization of various parts of the skeleton such as exists in terrestial animals. All the elements of the limb skeleton except the propodial have approximately the same function to perform and consequently all parts except the humerus and femur tend to become very much alike, and even the distal ends of these bones may lose their differentiated character and become mere rounded plates. The process is one of degeneration in which all the differentiation brought about by the varied stress of terrestrial life is lost and the bones become at last in the most extreme cases mere rounded plates — "Stützplatten" — with no characteristics by which one can be distinguished from another. These may be either closely set, "eine Pflaster von polygonalen Platten" (Fraas), as in most Ichthyosaurs, or separated by cartilage in which they are embedded, as in *Baptanodon* and *Ichthyosaurus ingens*. The propodial element retains in part at its proximal end its original function, — at least it continues to be the

portion by which the limb is attached to the girdle and by which the movement of the limb is possible, though even here the bone becomes much simplified, for the movements of the natatory limb are less complex and more restricted than those of the terrestrial type of limb. But, however much the propodial element may be reduced and simplified it is always recognizable as a propodial element. As much cannot always be said in regard to the epipodials, for in the most advanced cases, *e. g.*, certain Ichthyosaurs and Plesiosaurs, these bones are not distinguisable from the more distal elements except perhaps in the matter of size. In such a form as *Baptanodon*, and in fact in nearly all Ichthyosaurs above the Trias, there is an even gradation from the phalanges through all the bones of the limb up to and including the epipodials so that the limits of carpus and tarsus cannot be distinguished either from the epipodials or the digits. The metacarpals and the metatarsals are seldom distinguishable in any swimming limb from the phalanges, except sometimes by their larger size, and the phalanges in all cases (*Sirenia* excepted) taper off to a point.

The changes which take place in the epipodial region are perhaps the most interesting as well as the most marked of all. In the usual form of ambulatory limb the radius and tibia are quite different in function and in appearance from the ulna and fibula respectively, and they have quite different parts to play in the formation of the joints at their proximal and distal ends. In the natatory limb, with the loss of joint strain and freely movable joints, the function of the two bones becomes the same and they tend to take an equal part in the articulations at their proximal and distal ends and to become of the same size and shape. This tendency is seen even before the bones become much reduced in length, as in the Sirenia and Mysticocete whales. From this point on we have in the various groups all the stages in the evolution of the paddle to the point where the epipodials are merely rounded plates embedded in cartilage (*e. g.*, *Baptanodon*). The toothed whales have progressed farther than the whalebone whales, *Globiocephalus* being among the most modified, but the radius is always distinguishable from

the ulna. The Mosasaurs are still further advanced, especially the later forms, *Tylosaurus*, *Plioplatecarpus*, etc., and the radius and ulna approach each other in appearance pretty closely. Triassic Ichthyosaurs and most Plesiosaurs have the propodials evidently differentiated from the more distal elements though radius and ulna may be nearly alike in shape and size, and finally, in the later members of these groups they become indistinguishable from neighboring carpals and tarsals.

It is not strange that Gegenbaur, casting about for an incipient tetrapodial limb in connection with his "Archipterygium" theory, should settle upon the Ichthyosaur limb as the example which should connect the fin of the fish with the limb of the higher animal, or that Marsh, following the lead of Gegenbaur, should hail the discovery of *Baptanodon* as showing limbs "less specialized than those in any other known form above the fishes," the humerus alone being differentiated out of the "primitive cartilage." It remained for Baur to demonstrate that the Ichthyosaur limb is not the least but the most specialized, approaching the condition of the fish fin as an adaptation to aquatic life.

Elongation of Digits.

This factor in the formation of the swimming limb seems to be without exception. It is one of the earliest to appear, it occurs in all groups and apparently in all individuals and shows no tendency to be lost. Even in such a form as *Merriamia* or *Ichthyosaurus communis*, where the hind limb is evidently degenerating, the digits are still elongated in comparison with the remainder of the limb. In some forms all of the digits are elongated, and even extra digits added to the paddles may be greatly increased in length (cf. the sixth digit of many Ichthyosaurs), but in other cases certain digits only are elongated while the others retain their original size or even become greatly reduced. Thus in the hand of *Globiocephalus* the second and third digits are enormously extended while the first, fourth and fifth are quite degenerate, and in *Ichthyosaurus acutirostris* three greatly elongated digits are present while the other two, prob-

ably the first and fifth of the original pentadactyl limb, have vanished entirely.

The elongation of the digits may take place by an increase either in the length or the number of phalanges, — hyperphalangy. Undoubtedly the former method is the original one as we find it in many forms not otherwise greatly modified. The Pinnipedia, the marine Chelonia and the Thalattosuchia show only this modification. The earlier Mosasaurs show very little hyperphalangy while the phalanges are greatly elongated. The whalebone whales are much less modified in this respect than the toothed whales and in them the elongation is largely due to elongation of the bones, while in the latter group hyperphalangy coupled with a cartilaginous separation of the bones is the general mode. In the Plesiosauria and Ichthyosauria, and particularly in the latter group, hyperphalangy is developed to such an extent that it accounts entirely for the length of the digits. It is only in such early Ichthyosaurs as *Mixosaurus* and *Merriamia* that we can observe any characters of long bones present in the phalanges.

Hyperphalangy.

Several theories have been proposed to account for hyperphalangy. Howes has suggested an "intercalary syndesmosis" such as occurs in some Amphibia, the formation of a joint in the middle of a bone by ossification of the ends of the bone only, the joint appearing in the cartilaginous portion remaining, but there is no substantial evidence to support this theory in the reptiles and mammals.

Weber, Ryder and Baur have tried to prove that the additional phalanges were formed by the ossification of terminal or extradigital cartilages such as those that appear on the ends of the digits in the Pinnipedia, or to quote Ryder, "The cartilaginous extension of the ungual phalanges, I take it, has afforded the basis, in some ancestral seal-like form, for the development of an increased number of digits beyond the ungual phalanx, as in Cetacea." While there may be nothing in the nature of things to prevent such a process taking place,

there has never been any real evidence adduced to show that such ossification of extradigital cartilages really occurs. A third theory which has been more generally accepted than the ones just mentioned for the reason that a considerable amount of evidence has been brought to its support by its author, is Kükenthal's theory of "double epiphyses." These epiphyses by retarded ossification become separated from the shaft of the bone. Separated double epiphyses are commonly met with in Cetacea and Kükenthal mentions one case (*Hyperoödon rostratus*) in which they appear as separate bones even on the radius and ulna. Once separated as distinct bones these epiphyses would tend soon to become the same size as the bones from which they separated, owing to similarity of function. Double epiphyses in Mammalia would admit of as many as twelve phalanges in a single digit, while as many as eighteen might appear in the fourth digit of a reptile. These numbers are rarely exceeded and only by certain toothed whales among the mammals — *Globiocephalus* may have a maximum of seventeen — and by a few Ichthyosaurs, such as *I. communis*, among the reptiles. To explain such cases Kükenthal assumes the formation again of double epiphyses in these secondary phalanges, and finally the development, by retarded ossification, of a third set of phalanges. In this connection it is of importance to determine whether all of these groups of reptiles showing hyperphalangy possessed epiphyses. These structures at least appeared very early in some reptiles, and Kükenthal cites the case of a *Mesosaurus* from the Karroo formation, which possesses double epiphyses. On the other hand it is worthy of note that in the Chelonia, which according to Gadow do not possess epiphyses, forms like *Chelone* and *Thalassochelys* have developed remarkably long digits without any increase in the number of phalanges.

Hyperdactyly.

The presence of additional or supernumerary digits is known in only two groups, the Ichthyosauria and Cetacea. In the former group it occurs frequently, and as many as four extra digits or nine in all are known in one species, *Ichthyosaurus longimanus*.

In the Cetacea it is of rare occurrence, and never more than one extra digit is present. These extra digits always appear on the posterior side of the paddle. Baur offered the suggestion for the Ichthyosaurs that the sixth digit was produced by elongation of the pisiform or its homolog, but there is no direct evidence in favor of this view, while the breaking up of the digits toward the end in such a form as *Ichthyosaurus communis* indicates rather that they have been produced by a splitting of the digits. At any rate Baur's suggestion would not be sufficient to cover cases where more than one extra digit appeared. Kükenthal has shown in the case of the whales that the sixth digit is produced directly by the longitudinal splitting of the fifth.

As to the reason for the appearance of extra digits, Kükenthal has given what appears to me to be a very satisfactory explanation, and one for which he, together with Leboucq, has advanced considerable evidence in the whales. The extension of the swimming membrane on the posterior margin calls for extra support which is at first met by a widening of the last digit. Finally, retarded ossification causes a separation of the digit into two parts in somewhat the same way as the double epiphyses are separated from the diaphysis in hyperphalangy. Thus the need of widening the supporting area of the posterior border, together with the tendency toward the formation of smaller skeletal parts in the swimming limb, would account for the appearance of the additional digits.

Formation of Smaller Skeletal Parts.

This principle, which, I believe, Kükenthal was the first to mention, is exhibited by nearly all forms which have progressed so far in aquatic adaptation as to lose their land relation. It is best seen in the Ichthyosaurs, but the Cetacea, Plesiosaurs and later Mosasaurs also show it well. It is about coextensive with hyperphalangy by which it is in part produced, but it also involves the direct reduction in size of certain parts and a concentration towards the proximal end of the limb. The purpose is evidently to produce a limb that shall be uniformly flexible —

the type of limb best suited for locomotion in the water, as witness the fins of fishes with their many-jointed rays giving them an even flexibility.

Concentration of all Parts Except the Digits.

A little comparison will serve to convince any one that the elongated type of propodial and epipodials with which we are familiar in terrestrial forms is wholly unsuited to perfect locomotion in water. In all reptiles and mammals which have become permanently aquatic the shortening up of this region of the limb is so evident as to need little comment. The most highly specialized forms in this regard are found among the Ichthyosaurs in which the humerus may be so shortened that its length scarcely exceeds its breadth (cf. *Shastasaurus*), while the epipodials in nearly all cases are even shorter than wide. The Thalattosuchia (cf. *Geosaurus*) present the curious anomaly of a very greatly shortened fore limb, while the hind limb is little modified. Williston is probably right in thinking that this hind limb of *Geosaurus* was of little use in the water and was probably carried close to the tail in swimming, after the manner of newts. Among the Mosasaurs *Clidastes* and *Plioplatecarpus* seem to be the most highly specialized in this respect, while among the Plesiosaurs, *Cimoliosaurus*, and in the Cetacea, *Globiocephalus*, are among the most modified.

Another factor in the concentration of parts is the shifting of certain elements into new positions. Chief among these may be mentioned the shifting of the so-called "pisiform" or its homolog (cf. Baur "On the Morphology and Origin of the Ichthyopterygia") to a position alongside of the epipodials articulating with the humerus or femur ; the shifting of the fifth digit to articulate directly with the ulna as seen in some whales, perhaps best in *Globiocephalus*, and the Thalattosuchia ; and the massing together of the bones in the carpal and tarsal region against the ends of the epipodials, so that the intermedium is sometimes interlocked between their ends. Concerning the "pisiform" it is necessary to state that there is grave doubt as to the identification of this bone. Williston holds that the extra

bones in the epipodial series are not misplaced carpals and tarsals but new growths like supernumerary digits. This idea, however, is not entirely a new one, for Baur himself in the above-mentioned paper refers to it as "the pisiform or another element of a new-formed ray." Until we know more of this region of the limb, however, it will be impossible for us to determine whether the bone in question is a shifted mesopodial, as it may well have come to be during the concentration of this region, or an entirely new structure formed *in situ* perhaps by being split off from a neighboring bone. In the meantime it seems well to retain the name "pisiform" already in use and take it with the necessary grain of salt.

The shifted pisiform occurs only among the latest Ichthyosaurs (*Baptanodon* and *Ophthalmosaurus*) and Plesiosaurs (*Cimoliosaurus*). The most advanced condition noticed is that seen in *Cimoliosaurus trochanterus* where the pisiform lies partly alongside of the distal end of the humerus. The massing of the carpals and tarsals is best know in the Ichthyosaurs, where the bases of the digits are usually also massed, though it is shown equally well by some Plesiosaurs, *e. g.*, *Peloneustes*.

In some forms the same result of shortening may be attained by the reduction of the carpal and tarsal region, either in number or size of the bones or both. (Cf. *Delphinapterus*, *Phocæna*, *Balænoptera*, etc., among Cetacea, and *Tylosaurus* among the Mosasaurs).

Cartilaginous Progression in Joints.

Later forms always show the presence of more cartilage than their predecessors, and it is perhaps safe to say that the adaptation of a species to aquatic life may be measured by the amount of cartilage developed in the limb joints. The bones of the digits are usually merely separated by cartilage pads — longer near the tip where greater flexibility is desirable — but occasionally some of the phalanges may be entirely embedded. The carpal and tarsal bones in all groups tend to become embedded in cartilage, with excavated edges, set off from each other, reduced in shape to round plates or ossicles, and in some

cases finally lost. The Mosasaurs show an interesting series in this respect with stages marking all the steps from the Lacertilian type of carpus to that of *Tylosaurus proriger* which retains only one small round ossicle in the mesopodial region. The Ichthyosaurs also show many intermediate stages between the interlocked bones of the early Jurassic species and the cartilage-embedded ones of *Baptanodon.* In the Cetacea such forms as *Delphinapterus*, *Phocæna*, and *Balæna* are especially instructive. The ends of the epipodials and the distal end of the propodials may also become covered with cartilage to the extent that they are more or less evenly rounded, for all bones tend to take this rounded form when they become so embedded in cartilage that they are not affected by the impact of any neighboring bones.

Loss of Movable Articulations in the Limb.

All necessary movements of the natatory limb can best be made at the point of attachment of the limb with the girdle, all movements are of the limb as a whole, no flexing or torsional movements within the limb are required, no motion of certain digits or other special parts is necessary. Hence there is in all swimming limbs the tendency toward the reduction of all movable joints, the final result being the production of a more or less flexible paddle without power of special movement in its individual parts. Such we find it in the Cetacea, Ichthyosauria, Plesiosauria and Mosasauria and probably in the Thalattosuchia, and partially in the Sirenia, Pinnipedia and marine Chelonia. This may be attended by anchylosis of certain bones as in *Monodon* where humerus, radius and ulna are solidly united, or in *Manatus* where radius and ulna are anchylosed, but this never occurs except with proximal elements. More generally the bones are merely united by or embedded in cartilage, as this admits of a certain flexibility. In many Ichthyosaurs and Plesiosaurs the bones interlock quite closely without the interposition of a noticeable amount of cartilage, but in the latest forms of both these groups the cartilaginous embedding of the bones becomes evident. The marine Chelonia, which go on

shore to lay their eggs, and the Sirenia which have a peculiar use of the paddle when feeding and holding the young, have retained certain movable joints.

Loss of Tuberosities for Muscle Attachment.

Naturally, upon the loss of movable joints or the need of them, would follow the degeneration of the muscles of the limb and consequently of the muscle attachments. This is plainly evident in all the groups under discussion. The only tuberosities retained in the completely aquatic limb are those at the head of the humerus and femur for the attachment of those muscles which move the whole limb.

In conclusion the writer wishes to thank the American Museum of Natural History for the use of material, and especially to thank Professor Henry Fairfield Osborn for the use of his library and for many valuable suggestions during the progress of the work.

Addendum.

Since the above was written a very noteworthy paper by Professor John C. Merriam has appeared in the Memoirs of the California Academy of Sciences, May 5, 1905. In this paper Professor Merriam describes the "*Thalattosauria*," an entirely new order of marine reptiles from the Triassic of California. This group represents an offshoot of the primitive Diaptosauria and is most nearly related to the Rhynchocephalia, standing in relation to this group about as the Mosasaurs do to the Lacertilia, according to Merriam. The two genera, *Nectosaurus* and *Thalattosaurus*, in order of their specialization, exhibit no aquatic characters not already mentioned, but in regard to the aquatic adaptation of the limbs they fall in line in all respects with the groups already discussed in the foregoing paper. Only the propodial and epipodial elements are thus far known and these seem to be about as much specialized as those of the later Mosasaurs. The Thalattosauria are of interest in the present paper chiefly because they add one more to the list of separate

groups which have taken up marine life and which have developed a swimming paddle out of a terrestrial type of limb.

COLUMBIA UNIVERSITY,
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PLATE VII

PLATE VII.

1. *Mixosaurus*, fore limb, — after E. Repossi.
2. *Mixosaurus*, hind limb, — after E. Repossi.
3. *Delphinosaurus perrini*, fore limb, — after Merriam.
4. *Shastasaurus osmonti*, fore limb, — after Merriam.
5. *Ichthyosaurus acutirostris*, hind limb, — after Fraas.
6. *Toretocnemus californicus*, hind limb, — after Merriam.
7. *Ichthyosaurus communis*, fore limb, — after Lydekker.
8. *Ichthyosaurus communis*, hind limb, — after Lydekker.
9. *Ichthyosaurus quadriscissus*, fore limb, after Fraas.
10. *Ichthyosaurus ingens*, fore limb, — after Fraas.
11. *Baptanodon natans*, left hind limb, — after Marsh.
12. *Plesiosaurus dolichodeirus*, fore limb, — from Hawkins' Book of Great Seadragons.
13. *Plesiosaurus dolichodeirus*, hind limb, — from Hawkins' Book of Great Seadragons.
14. *Cimoliosaurus eurymerus*, fore limb, — after Lydekker.
15. *Cimoliosaurus portlandicus*, hind limb, — after Lydekker.
16. *Cimoliosaurus trochanterus*, fore limb, — after Lydekker.
17. *Peloneustes*, fore limb, — after Lydekker.
18. *Geosaurus suevicus*, fore limb, — after Fraas.
19. *Geosaurus suevicus*, hind limb, — after Fraas.
20. *Dacosaurus*, lateral and anterior views of humerus, — after Fraas.

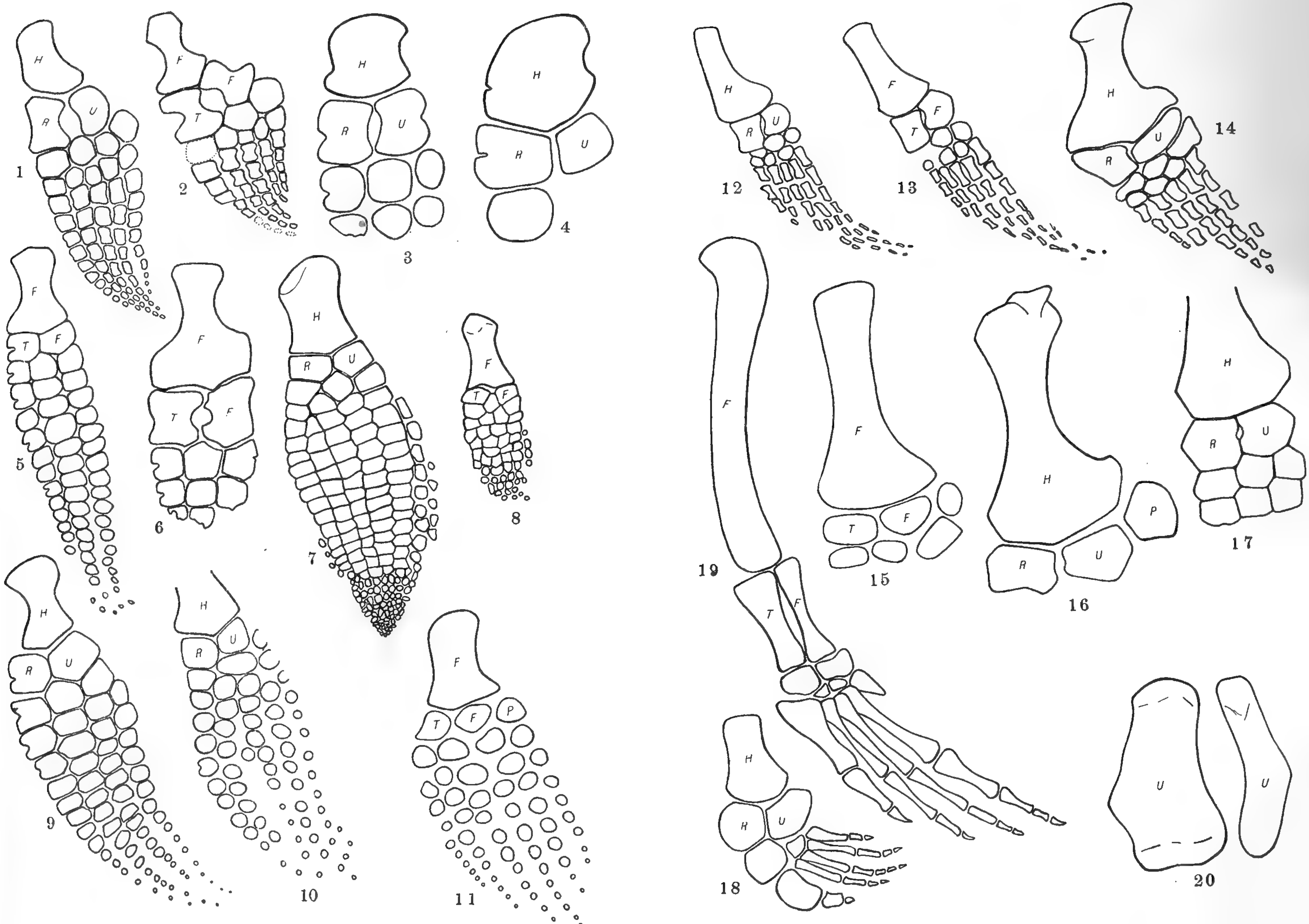
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PLATE VIII.

PLATE VIII.

21. *Mosasaurus lemoinieri*, hind limb, — after Dollo.
22. *Platecarpus coryphæus*, hind limb, — after Williston.
23. *Plioplatecarpus marshii*, fore limb, — after Dollo.
24. *Brachysaurus overtoni*, humerus, — after Williston.
25. *Tylosaurus proriger*, fore limb, — after Williston.
26. *Clidastes velox*, fore limb, — after Williston.
27. *Mosasaurus horridus*, fore limb, — after Williston.
28. *Platecarpus ictericus*, fore limb, — after Williston.
29. *Manatus*, outer aspect of left limb, — original.
30. *Monodon monoceros*, left hand of embryo of 24 cm., — after Kükenthal.
31. *Balæna mysticetus*, hind limb and girdle, — after Flower.
32. *Monodon monoceros*, outer aspect of left fore limb, — original.

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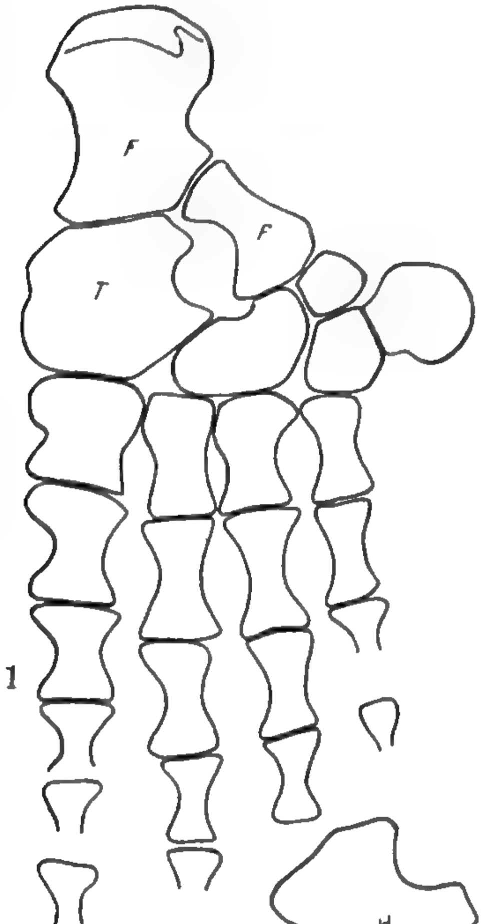

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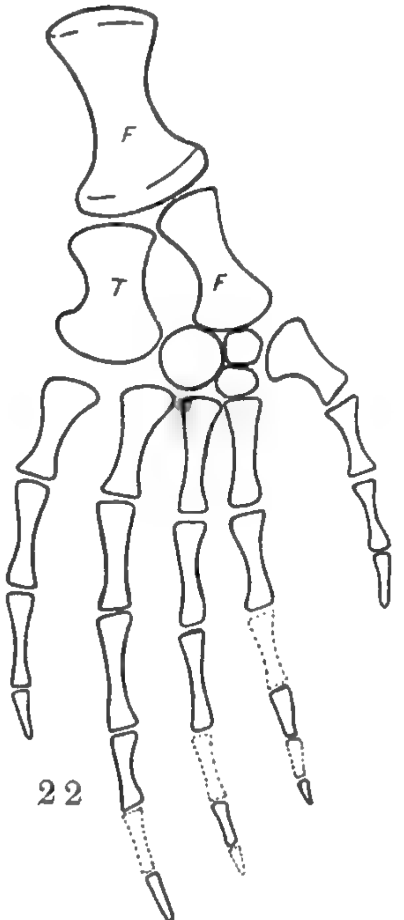

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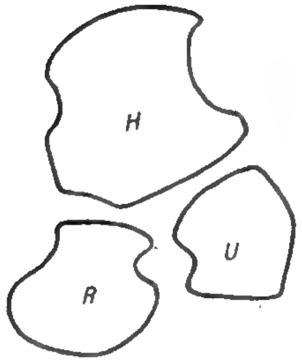

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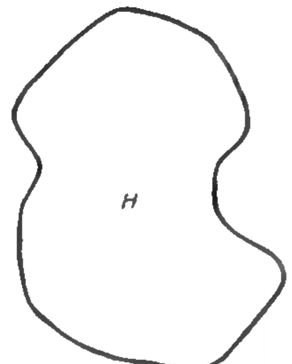

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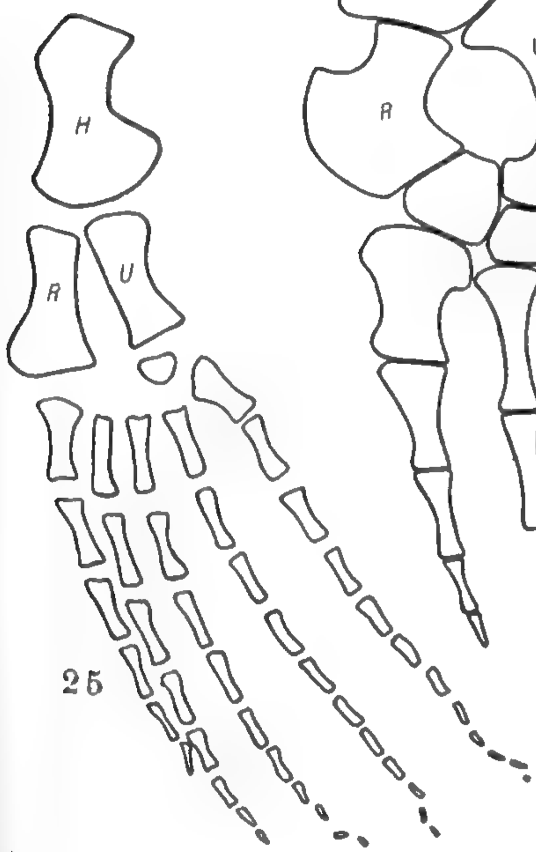

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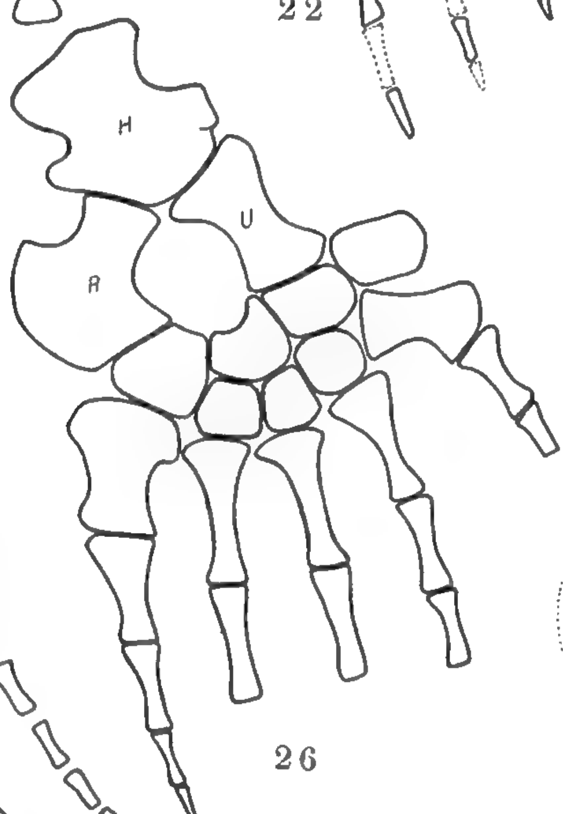

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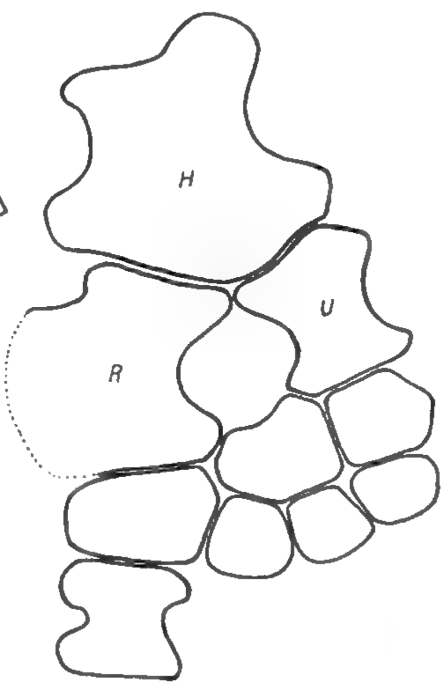

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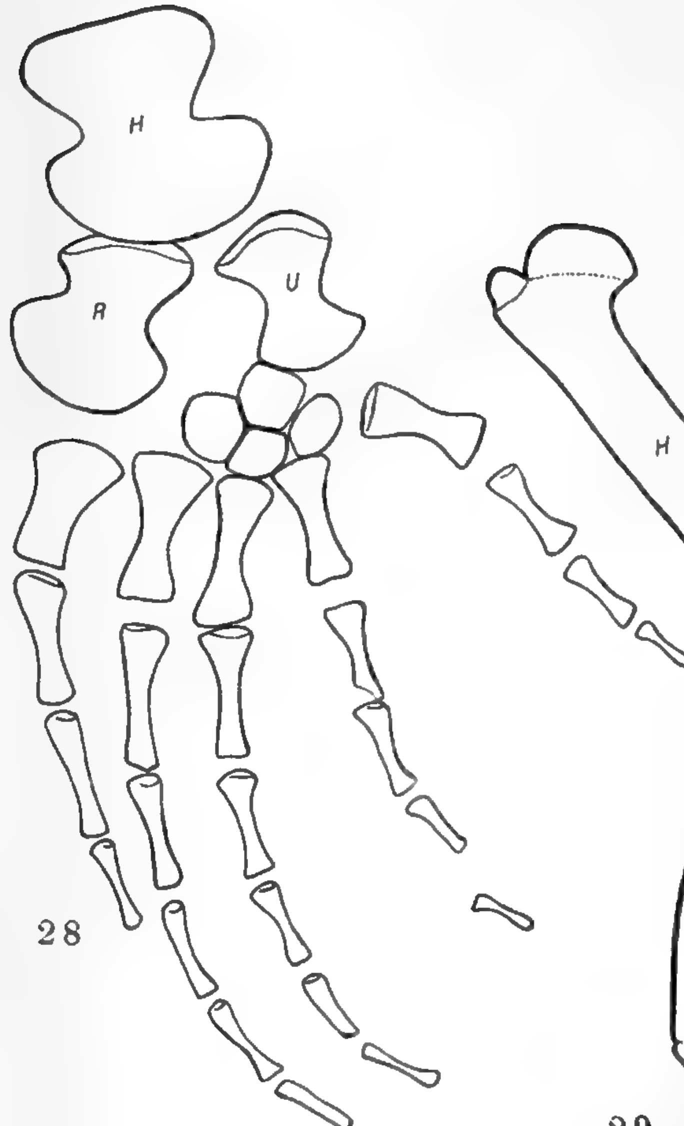

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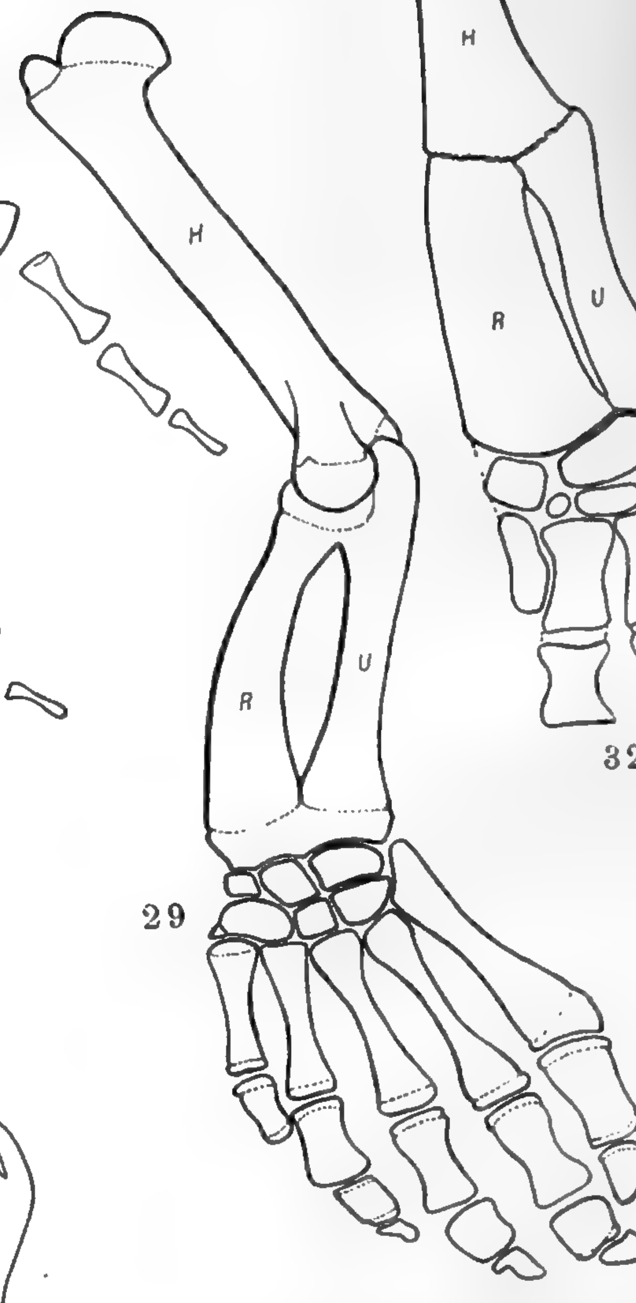

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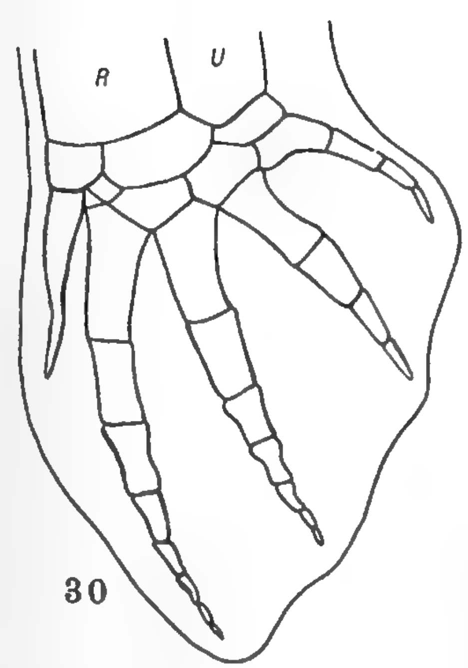

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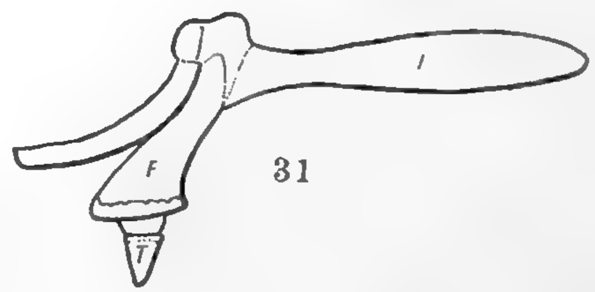

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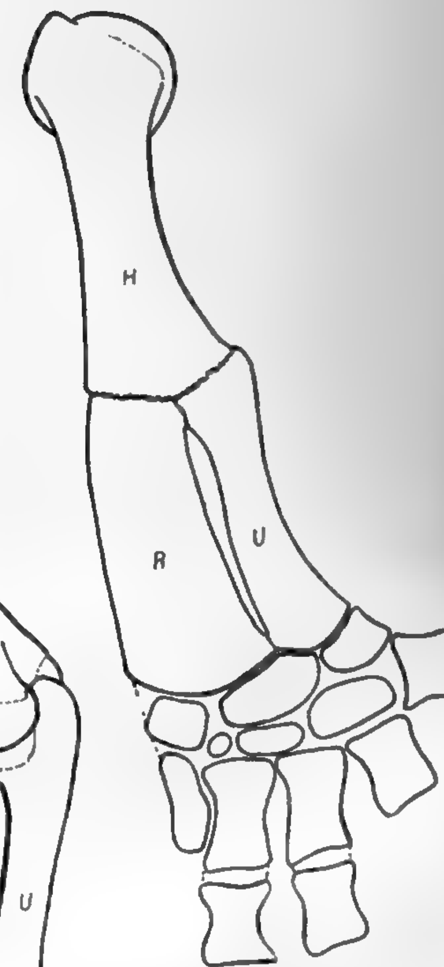

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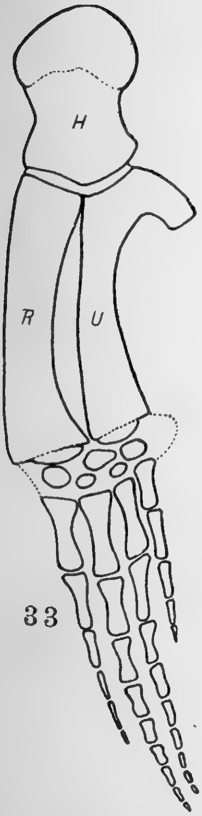
PLATE IX.

PLATE IX.

33. *Balænoptera intermedius*, hand of young, —after Burmeister.
34. *Balænoptera bonaërensis*, hand, —after Burmeister.
35. *Delphinapterus leucas*, young, — original.
36. *Globiocephalus melas*, —after Flower.
37. *Phocæna communis*, outer aspect of left fore limb, —original.



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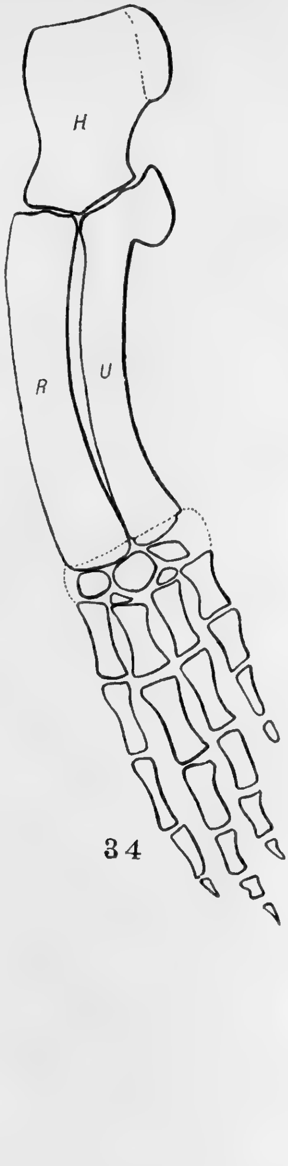

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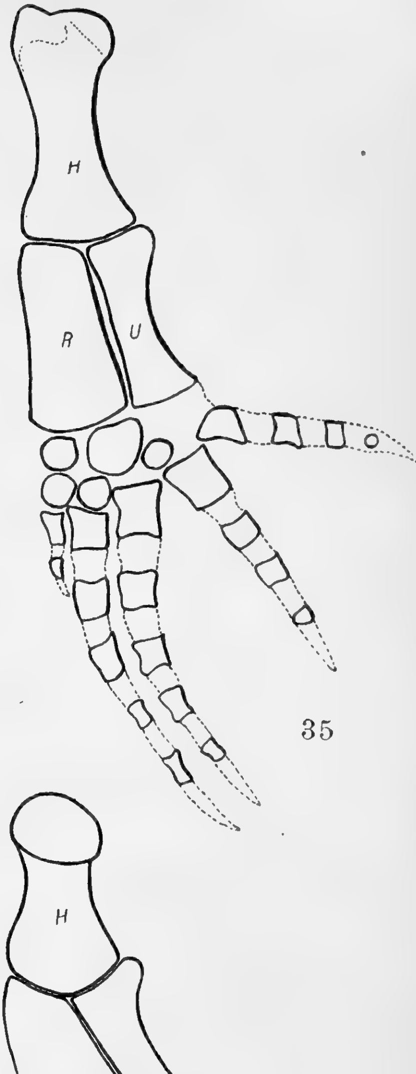

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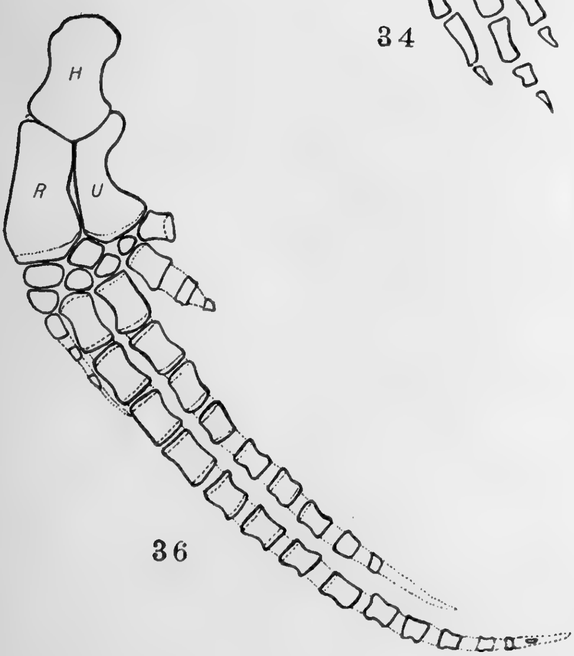

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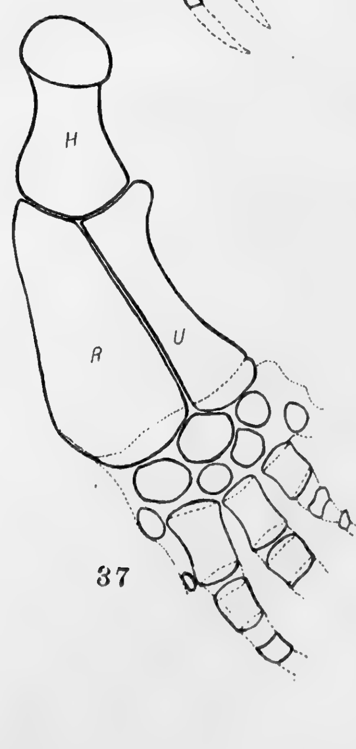

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